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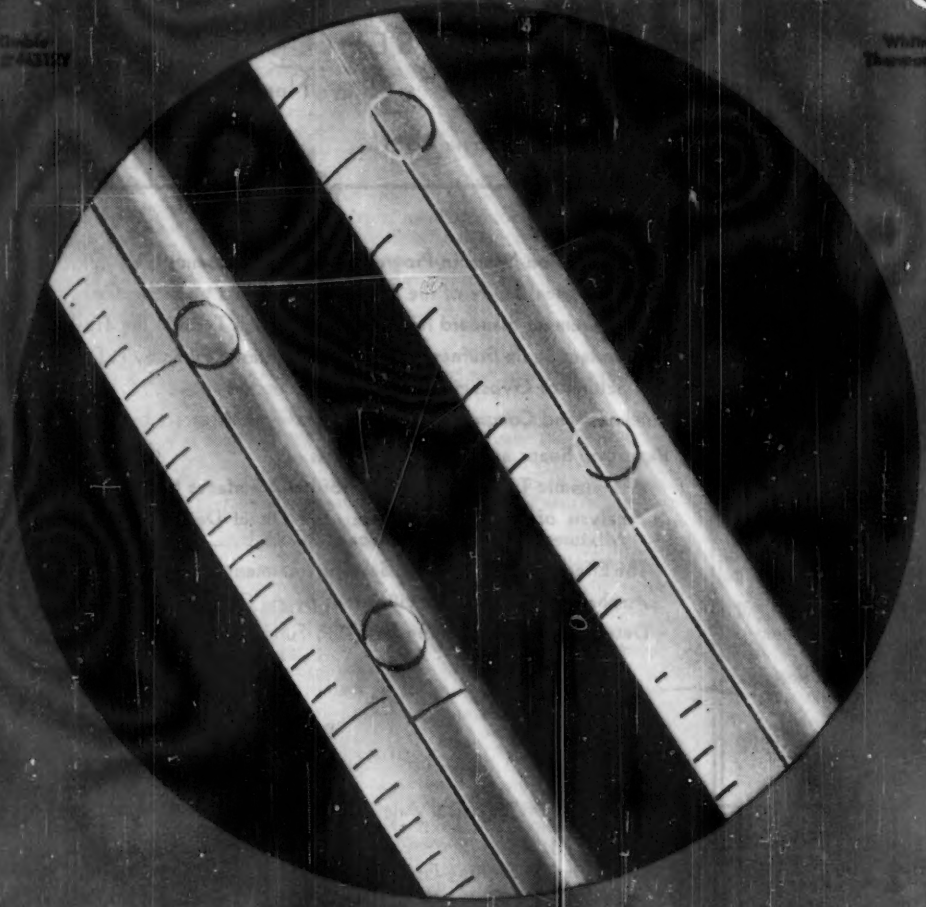

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ASTM BULLETIN

"Promotion of Knowledge of Materials of Engineering, and Standardization of Specifications and Methods of Testing"

Number 192 SEPTEMBER, 1953

Standardization Work in Progress in Technical Committees

Round-Up of Work Programs Reveals Great Activity

In recent years it has been the practice to feature in a Fall issue of the Bulletin a review or round-up of the most important standardization activities in progress in the Society's technical committees. This year's look ahead provides a broad concept of the developmental tasks now being undertaken.

The information included in this article is based in part on current reports of the technical committee and on committee work programs sent into Headquarters by the officers.

A-1 Steel

Structural Steel: A proposed specification for a structural welding grade of steel is under preparation. This is based upon the requirements of a welding grade of structural steel recently adopted by the American Welding Society's Bridge Code Committee.

Recommended changes in Specification A 242 for Low-Alloy Structural Steel include a change of title, an increase in the thickness limitation from "2 in." to "4 in.," and minor changes in chemical and tensile requirements.

Reinforcing Steel: It is intended to revise the cold bend test requirements in Specifications A 15 for Billet Steel Bars for Concrete Reinforcement. In general this will impose smaller diameter bends on the deformed bars covered by these specifications. Also in Specifications A 15, A 16, and A 160 covering reinforcing bars a proposal will waive the cold bend test requirements for plain bars which will be used in unbent form, such as load transfer dowels.

Forgings: A new Tentative Specification for Carbon and Alloy Steel Forgings for Pressure Vessel Shells will probably be referred to the Society for publication late this year. This specification is intended primarily for lightweight pressure vessels such as gas cylinders. Another new specification for testing and inspection of closed die forgings will be developed. It is realized that such a specification could not cover the chemical and mechanical properties of this product at present, but this important class of steel products deserves recognition.

Tubular Products: In Specifications A 312 for Seamless and Welded Austenitic Steel Pipe it is proposed to revise the supplementary requirements on number of tension tests and flattening tests.

In Specifications A 199, A 200, and A 213 covering heat-exchanger, condenser, still, boiler, and superheater tubes, grade T3 (nominal 1.75 Cr, 0.75 Mo) will probably be withdrawn. Also in Specifications A 200 and A 213 the silicon content range of grade T9 (nominal 9 Cr, 1 Mo) may be changed from "0.50 to 1.00" to "0.25 to 1.00" per cent. The same change will be made in grade P9 of Specifications A 335.

Two new specifications are in prospect. Proposed Tentative Specifications for Forged and Bored Pipe are expected to be submitted for publication this year. New proposed specifications for austenitic steel pipe suitable for high-pressure high-temperature applications are being developed and are in the subcommittee stage.

Boiler Plate: In line with actions taken several years ago in steel tubular specifications, the chemical requirements in the boiler plate specifications will be broken down into ladle and check analysis limits.

A new specification for flange and firebox quality plates 1 in. and under in thickness is being drafted, taking into consideration the highest mechanical properties possible in a good weldable carbon steel.

Sheet and Strip: Two Proposed Specifications for Hot-Rolled and for Cold-Rolled Low-Alloy High Tensile Strength Sheet and Strip are being considered in subcommittee.

Bar Steel: A "ruling section" type of specification for bar steel (such as MIL-S-11415A) is under preparation. This specification would be a guide to designers in pointing out the capabilities of bar steels for developing mechanical properties by heat treatment.

Bolting: A description of testing methods peculiar to fasteners is planned to be added as a supplement to the Tentative Methods and Definitions for the Mechanical Testing of Steel Products (A 370 – 53 T).

The Society of Automotive Engineers and ASTM have been collaborating in bringing A 325 and the similar SAE Specification for bolting into line. This includes mechanical properties and head marking. Specifications A 354 for Quenched-and-Tempered Alloy Steel Bolts and Studs with Suitable Nuts will probably be revised to acknowledge use of this material for limited application at elevated temperatures. A head marking for grade BD material is also being established.

Emergency Alternate Provisions: In 1951 and 1952 numerous emergency alternate provisions for steel specifications were enacted because of the government restrictions on the use of molybdenum. Now that government restrictions have been lifted, action is being taken to withdraw the emergency alternate provisions dealing with molybdenum content of steels in numerous specifications.

A-5 Corrosion of Iron and Steel

Initial work has begun on the preparation of a recommended practice for safeguarding against warpage and distortion during hot-dip galvanizing of steel assemblies; also specifications for hot-dip zinc coatings on miscellaneous fabricated or assembled steel products and specifications for zinc-coated armor wire and for zinc-coated poultry and turkey run netting.

Consideration is being given to revisions in a number of standards as follows:

1. The Standard Method of Test for Weight and Composition of Coating on Long Terne Sheets by the Triple Spot Test (A 309) is being studied with a

view to including other methods of test.

2. Specifications for Zinc-Coated Iron or Steel Sheets (A 93) and Specifications for Long Terne Iron or Steel Sheets (A 308) are being studied further to resolve a controversial section having to do with number and degree of defects in coils.

3. Clarification of the sampling procedure is all that is required to complete the revision of A 112, Standard Specifications for Zinc-Coated Iron or Steel Tie Wires.

4. A lack of agreement on size tolerances as well as differing opinions relative to the deletion of the Preece Test requirement has delayed revisions in A 117, Specification for Zinc-Coated Iron or Steel Chain Link Fence Fabrication, Galvanized after Weaving.

5. A Section on Strand is to determine whether the specifications for Zinc-Coated Overhead Ground Wire Strand (A 363) should be modified to include additional constructions or sizes.

Although the results will not show up in the standards activities of the committee immediately, nevertheless, the long term data resulting from a new exposure test on hardware that is now contemplated will have a bearing on future work of the committee.

A-6 Magnetic Properties

FOUR active task groups are working on (*a*) specifications for electrical sheet and strip, (*b*) normal variability of magnetic properties of electrical sheet, (*c*) a manual of magnetic testing to supplement the standard testing specifications, and (*d*) a thoroughgoing revision of the specifications for a-c testing.

A-10 Iron-Chromium Alloys

SEVENTEEN laboratories are cooperating in a round-robin test program to compare the oxalic acid etching technique[1] as a means for screening stainless steels from the boiling nitric acid test (A 262).

A special subgroup is engaged in drafting requirements for the boiling acid copper-sulfate evaluation test for stainless steels.

The final draft of a recommended practice for the cleaning and passivation of stainless steel equipment has been referred to the committee for appropriate action.

A special group is preparing a report on the mechanical properties of the extra low carbon grades of stainless steel, 304L and 316L.

The Subcommittee on High-Temperature Super-Strength Alloys has appointed a task goup to prepare a complete listing of all available super-strength alloys. Upon completion of this list, specifications will be written for one each of the following: (*a*) hot-cold work, (*b*) precipitation aging, and (*c*) cast super-strength alloys.

B-1 Wires for Electrical Conductors

THE subcommittee on test ing methods and sampling procedures is considering the desirability of ultimately developing statistical sampling procedures for tinned copper, alloy-coated copper, and hard-drawn aluminum wire. Such sampling procedures are already included in Specifications B 1 and B 3 for hard-drawn and soft copper wire, and have been well received in the industry.

Proposed specifications for soft or annealed coated copper conductors for use in hookup wire for electronic equipment are being developed in the subcommittee concerned with conductors of copper and copper alloys. The need for specifications to cover silver-plated wire or other plated or coated wires for higher-temperature applications is being considered.

There has been considerable discussion on the standardization of direction of lay of stranded aluminum conductors in the subcommittee on conductors of light metals. Other projects include standardization of large sizes of stranded aluminum conductors, standardization of additional constructions of ACSR conductors, preparation of a proposed specification for annealed or one-quarter hard aluminum wire for telephone cable applications, and development of proposed specifications for aluminum magnet wire.

B-2 Non-Ferrous Metals and Alloys

ONE of the most important tasks before this committee is to develop standard specifications on titanium sponge as an aid to the Government in purchasing such material for the Armed Forces and for storage in a revolving stockpile until needed. This work is complicated by the fact that there are only two main producers at present, with products varying widely in composition.

Another project that offers difficult problems is to develop a proper classification of tin to fit the various applications of this metal. The problem here is complicated by insufficient information on the precise effect of some impurities, alone or in combination, on the properties of the coating or alloy made from the tin. Also, problems of toxicity from impurities in the tin add a complicating factor.

Considerable work lies ahead on preparing specifications for the Hastelloy type of nickel alloys, for high-nickel alloy castings, and in revision of various tentative specifications on nickel and nickel-base products. Other activities include revising certain copper specifications, redrafting a tentative specification for resin-cored solder, and devising a test for continuity of coating of lead-coated copper.

B-3 Corrosion of Non-Ferrous Metals

A RECENT study has indicated the acetic acid-salt spray test to be as effective as the regular salt spray test for determining the quality of copper-nickel-chromium or nickel-chromium coatings on steel. Further studies are being made to verify these early results.

An interim report has been presented to Subcommittee VII on Weather indicating the information to date resulting from a survey of instruments and methods for measuring atmospheric pollution, particularly with respect to the presence of corrosive gases.

A number of exposure programs are under way including (*a*) non-ferrous specimens which have been preserved from the tests initiated in 1931, (*b*) calibration of various atmospheres using iron and zinc specimens, (*c*) disk-type galvanic couples (the first of three groups has now been removed), (*d*) completion of a galvanic spool-type specimen program, and (*e*) solicitation of materials in conjunction with plate-type galvanic specimens.

B-4 Electrical Heating, Resistance Alloys

A CONSIDERABLE amount of work is being applied toward the development of new specifications including nickel-clad steel, aluminum-clad steel, nickel-plated steel, and aluminum-plated steel. General specifications for mica stampings are being studied in conjunction with the work of Committee D-9 on Electrical Insulating Materials. This group is also working on the determination of gas content and on general test methods for mica prior to the fabrication of stampings. Three

[1] M. A. Streicher, "Screening Stainless Steels from the Nitric Acid Test by Electrolytic Etching in Oxalic Acid," ASTM BULLETIN, No. 188, February, 1953, p. 35.

laboratories are working on a project to develop a standard triode with the aim of overcoming some of the deficiencies of the present standard diode (B 270).

B-5 Copper and Copper Alloys

Now under consideration by the main committee are the following items:

1. In Specifications B 11 and B 12 for Copper Plates and Rods, add a minimum yield strength requirement of 10,000 psi when the material is used for ASME Boiler Code construction.
2. For alloy E (aluminum bronze) of Specification B 171 for Condenser Tube Plates, add a copper content range of 78.0 to 85.0 per cent.
3. In Specification B 138 for Manganese Bronze Rod, Bar, and Shapes, clarify the dimensional tolerances for hot-forged rod and bar.
4. For Alloy No. 3 in Specification B 135 for Seamless Brass Tube, change the lead content range from the present "0.3 to 0.8" to be "0.2 to 0.8" per cent to facilitate manufacture of the alloy in die-scalped tubes for redrawing.
5. In General Requirements Specification B 251, add a definition for average diameter for tubes; revise the wall thickness tolerance for $\frac{1}{4}$-in. Type K water tube; and delete straightness tolerances for water tube.

Two proposed specifications are in their final stages in subcommittees. These are the Proposed Tentative Specification for Copper and Copper-Alloy Die Forgings and the Proposed Tentative Specifications for Nickel-Tin Bronze Sand Castings. Also in General Requirement Specification B 251 a revision of lot size requirements for sampling large-size pipe and tube has reached the same status.

The committee expects to present most of the following items to the Society for action in 1954. At the present they are being investigated by various subcommittee task groups:

1. Establishment of yield strength values for pipe and tube materials used in ASME Boiler Code construction.
2. Preparation of requirements for 10 and 12 per cent nickel-silver sheet, rod and wire.
3. In Specification B 75 for Seamless Copper Tube more detailed listing of tempers and Rockwell hardness.
4. Revision of the dimensional tolerances in Specification B 111 for Condenser Tubes.
5. The addition of dimensional requirements for rectangular and square copper bus tube furnished to Specification B 188.
6. In Specification B 135 for Seamless Brass Tube, the addition of more detailed straightness tolerances.
7. In General Requirement Specifications B 248, B 249, B 250, and B 251 a study of the sampling and retest requirements in reference to statistical quality control. In this endeavor the committee is being counseled by Committee E-11.
8. In Specifications B 96, B 97, B 98, and B 99 for Copper-Silicon Alloys, the deletion of inactive alloys and simplification of remaining chemical requirements.
9. Proposed specification for manganese brass sheet for resistance welding.
10. Proposed recommended practices for the measurement of dimensions.
11. Revisions in methods for determining grain size.
12. Proposed classification of wrought copper alloys.
13. The correlation of Rockwell hardness and tensile strength values.
14. Revision of requirements for the expanding test in Specifications B 111 for Condenser Tubes.
15. Deletion of the microscopic examination for cuprous oxide in type DHP copper.
16. Revision of chemical requirements in Specification B 198 for Silicon Bronze and Silicon Brass Sand Castings.
17. Preparation of tables for chemical and physical requirements in Specification B 271 for Centrifugal Castings.
18. For recommended Practice B 208 the preparation of an appendix covering a code of procedure for the inspection of sand castings.

B-6 Die-Cast Metals and Alloys

A CONSUMER guide for the selection of a proper die-cast alloy for a particular application, and revisions in the typical mechanical properties table of the Appendix of Tentative Specifications for Aluminum-Base Alloy Die Castings (B 85) are nearing completion.

A new series of exposure tests of aluminum alloy SC84 with various amounts of zinc up to 2 per cent is on exposure at Kure Beach, N. C., New York City, and Columbus, Ohio, for 1, 3, 6, and 12-year periods.

A task group is studying the effect of iron content in the brass die-casting alloy ZS331A with the aim of raising the iron limit in the specification for this alloy from 0.15 to 0.25 per cent if it can be done without producing any deleterious effects.

B-7 Light Metals and Alloys

THE addition of minimum yield strength requirements for aluminum-base alloy sand castings (B 26) and aluminum-base alloy permanent mold castings (B 108) is being considered when these alloys are required for such applications as pressure vessels.

The bus bar specification (B 236) is currently being revised and a new specification is under consideration to cover other forms of bus conductors than those included in B 236.

A tabulation of the properties and characteristics of magnesium casting alloys for revision of Tentative Specifications for Magnesium-Base Alloy Sand Castings (B 80) is being undertaken in cooperation with the American Foundrymen's Society. Investigation of statistical sampling methods as applied to testing mechanical properties is continuing, but difficulty is being encountered in establishing lot sizes to be used in defining a statistically satisfactory sampling method for the frequency of mechanical testing requirements of the B-7 specifications.

Subcommittee VI on Anodic Oxidation has extended its scope to include anodic oxidation of magnesium alloys. Progress is being made on developing specifications for anodic coatings for various applications and compiling of engineering data on the characteristics affecting the performance of anodic coatings on the various aluminum alloys and products.

Supplementing the work on codification of light metals and alloys which resulted in the issuance of B 275 last year, effort is now being directed toward the development of a recommended practice for codification of tempers.

An interim report on the results to date of the B-7 exposure program which includes 27 aluminum and 8 magnesium alloys was given by L. H. Adam in an appendix to the B-7 Report, entitled "Atmospheric Exposure of Light Metals and Alloys."

B-8 Electrodeposited Metallic Coatings

THE comparison of ratings, made by members of an inspection group, of exposed plated panels has long been under question. Committee B-8 has now developed a new method of rating exposed panels, the details of which are included in a progress report of Subcommittee II appended to the 1953 report of the committee. If this rating system works out as it is hoped, it will subsequently be submitted to the Society for adoption as a standard.

A survey is currently being conducted

to survey the field of alkaline cleaning of materials. A new section has been appointed, having been charged with surveying the field of surface treatments of lead.

C-1 Cement

PREMATURE stiffening of cement has been discussed in Committee C-1 for some time, and a new working committee has now been authorized first to define what is meant by premature stiffening, then study the factors, and develop a method of test. The acceptance of a new tentative method for mechanical mixing of hydraulic-cement mortars of plastic consistency has led to extensive series of tests in several of the working committees to determine the effect of machine mixing on standard mortars in relation to the various properties.

A cooperative series of tests for the development of a performance standard for sulfate resistance of cement has been formulated, using a new approach to the problem. New tests for measuring time of setting are also being developed. With the acceptance of an expansion limit in the specification for masonry cement, details of the autoclave test procedure are now receiving concentrated study.

In the field of cement analysis, the investigation of various types of flame photometers that might be suitable for cement analysis is continuing, as is also a study of methods for the direct determination of alumina. The factors involved in workability are receiving attention, together with consideration of a definition of the term and tests for measuring the various factors.

A specification for portland-pozzolan cement is now in its final stages of development. The new working committee on the study of specifications for slag cement has prepared a specification which will be reviewed by the committee.

C-2 Magnesium Oxychloride and Oxysulfate Cements

DEVELOPMENT of test apparatus has been a necessary preliminary to describing a test method for shear strength of bonding media for magnesium oxychloride cement. Committee C-2 plans to cooperate with Committee C-3 on Chemical-Resistant Mortars on the development of a shear test which can be used by both committees. The Kessler machine used in ASTM Method C 241 is being studied for determining wear of oxychloride cement compositions with necessary modifications. This method uses bulk specific gravity to determine the wear. A water resistance test of compositions has received preliminary attention, using a 7-day immersion test, rather than 30 days. The use of an autoclave test to determine soundness of oxychloride cement compositions is being investigated, with modification of equipment being found necessary. A report is in process on active lime determination.

C-3 Chemical-Resistant Mortars

SILICATE-cement mortars, being one of the family of chemical-resistant mortars within the scope of Committee C-3, will be studied in terms of the chemically set type only, inasmuch as the majority of these mortars currently in use in acid-proof construction is of this type, rather than the air-setting type. It is felt necessary to redefine silicate mortar on a basis which would include all materials now in use. The new tentative methods of tests for tensile and compressive strength of resin mortars are now being further reviewed looking toward possible revision. Attention is being given to a final draft of a proposed method of test for chemical resistance of resin mortars.

C-4 Clay Pipe

STUDIES have been under way in Committee C-4 on the effect of a faster rate of loading on the ultimate breaking strength of clay pipe. Further attention will be given to the inclusion of a factor of safety when the pipe is tested by the slower rate of loading. Further consideration is also being given to a suggested elimination of the 80 per cent clause in the acceptance of rejection of clay pipe on results of tests. A task group has been appointed to study a proposal for increasing the crushing strengths of standard strength clay pipe to meet those of unreinforced concrete pipe. With the acceptance of a new tentative specification for clay flue lining, it has been decided to give further attention to amplifying these specifications with the addition of suitable physical and service qualifications.

C-7 Lime

THE autoclave test on lime for soundness has been studied over a long period. The most recent test data obtained by the committee still indicate considerable difference of opinion among six cooperating laboratories in comparing cement with gypsum as a basis for an autoclave test. More cooperative testing will continue to determine the correct limit to use. New methods of testing lime for available lime, iron, and the use of the versenate method, are still being studied.

The new Tentative Specification for Mortar for Unit Masonry (C 270), developed by Committee C-12, on Mortars for Unit Masonry, has been studied by the Subcommittee on Structural Lime, and suggested revisions are being made.

C-8 Refractories

INCLUDED in the several proposed test methods under consideration are: the measurement of modulus of rupture of trapezoidal and circle brick; the effects of rate of heating on the spalling test; a spalling test for high-fired blast-furnace brick; and a cooperative study of the determinations of alkalies in refractories by the flame photometer method. A study of a test for refractory dolomite has been started by the Subcommittee on Basic Granular Refractories as the first of the materials coming under its jurisdiction.

Further augmentation of the series of industrial surveys prepared and published by the committee, as well as revision of existing surveys, is showing substantial progress. New surveys being considered cover service conditions in open-hearth hot metal mixers, the paper industry, and reheat and annealing furnaces. Other survey topics include blast furnaces, insulation of refractories, cupolas, and the zinc industry.

C-9 Concrete and Concrete Aggregates

STANDARDIZATION projects include a wide range of test methods and specifications. With considerable progress already having been accomplished in the study of chemical reactions of aggregates in concrete, further attention is being given to a rapid and accurate test for reactive cement-aggregate combinations, which is urgently needed. Pore space in concrete aggregates will now receive more intensive study by the Subcommittee on Mineralogical Characteristics. The effect of the mineral or lithological com-

position of aggregates on the bond with cement paste will also be given attention by this subcomittee.

Further refinements of the flexure test method are under consideration. The preparation of a method of test for volume changes of concrete aggregates is now being checked for reproducibility in a number of laboratories. The inclusion in concrete aggregates specification of definite limits on mortar bar expansion test as a criterion of alkali reactivity is under serious consideration.

Following the completion of two proposed tentative specifications for lightweight aggregate for use with concrete masonry units and structural concrete respectively, work is continuing on a third specification to cover lightweight insulating concrete. A special group has been designated to review the latest draft of a proposed specification for fly ash, which has received considerable study and discussion over the last three years. It is expected that agreement may be reached on a specification at the Fall meeting of Committee C-9.

A long-awaited revision of the Specifications for Ready-Mixed Concrete (C 94) is closer to accomplishment, as in dicated by a series of changes now receiving attention by the subcommittee. Information is being collected on the subject of bleeding of concrete as effected by the grading of aggregates, effect of bleeding on presetting cracking of slabs, and effect of bleeding on scaling and durability of concrete slabs. Consideration of data collected on cooperative series embracing several types of abrasion apparatus has now led to the elimination of certain types of apparatus and it is planned now to conduct test series on one type only, which uses the dressing wheel apparatus. An extensive series of cooperative tests is being undertaken to establish data on a method of test for setting time of concrete.

C-12 Mortars for Unit Masonry

A RESEARCH study on the pointing of mortars is actively being pursued by the Subcommittee on Research. Further revisions of the Tentative Specification for Mortar for Unit Masonry (C 270) are being considered, including a suggestion that the current types A-1 and A-2 mortars be combined into one, with a minimum strength requirement and a lime content being specified. Work on the study of efflorescence is continuing, following the preparation of a paper dealing with the results of cooperative tests, which will be published in the ASTM BULLETIN.

C-13 Concrete Pipe

THE standardization activities of the committee are divided into long-range planning and short-term projects. On a long-range basis, studies will be made on developing a theoretical method for designing reinforced concrete pipe to withstand specified test loads; a comprehensive series of tests on reinforced-concrete pipe by the three-edge bearing method for the purpose or checking new methods of design as developed, to relate strength tests to minimum design requirements, and to obtain information on large diameter pipe; a study of the necessity for specifying load at 0.01-in. crack; and the elimination of the sand-bearing test as an alternate to the three-edge bearing test.

Projects under immediate consideration concern the desirability of using drilled cores for testing the compressive strength of concrete in concrete pipe. A special subcommittee is now preparing a proposed specification for reinforced concrete low head pressure sewer pipe. Several detailed revisions of the existing ASTM specifications on concrete pipe are under consideration.

C-14 Glass and Glass Products

NEW procedures for inclusion in the chemical analysis of glass sand are being completed by Committee C-14 covering the determination of lime and magnesia. In studying chemical properties, specifications for water are being considered for use in the glass durability test. Proposed methods dealing with physical and mechanical properties of glass being studied are the measurement of softening, strain, annealing points, and the expansion of glass. A separate study is being made of flexure testing of glass.

Revisions are under way which will modify the Tentative Method of Sampling Glass Containers (C 224) and the glossary of glass terms (C 162).

I would like to recommend to the majority of American business the lesson that a large minority of American business has already learned. It is this: that one of the last major areas where production and distribution costs can be cut lies in the application of standards techniques. —ROGER E. GAY
President ASA

C-15 Manufactured Masonry Units

A NEW field of standardization work was approved at the last meeting of Committee C-15, which will involve the study of waterproofing materials for unit masonry. Further attention is being given to the subject of sulfur capping *versus* cement-gypsum or plaster-of-Paris capping in respect to the effect on the apparent compressive strength of the specimen. The problem of shrinkage control of concrete masonry walls is being approached by a task group which will study the moisture content limitation and low volume change proposals.

The preparation of a proposed tentative specification for brick-block units will now be completed for presentation to the committee as a result of a one-year study by a task group. This unit, because of its volume of voids and cross-sectional design, does not fall into either brick or tile classification. Revisions are in process in the standard for chemical-resistant units (C 279) and the tentative on drain tile (C 4).

C-16 Thermal Insulating Materials

ADDITIONAL specifications are being prepared on the various types of materials in this field. These specifications include mineral wool, thermal insulating board for roofs; mineral wool block or board for elevated as well as low temperatures; cellular glass insulating block; calcium silicate block and pipe covering; and cork board.

A development of a method of test for determining flame resistance continues to be the subject for much discussion and study. A racking load test for structural insulating board and sheathed wall panels is nearing completion. Methods of tests for measuring weight adhesion of thermal insulating cement are being prepared. The determination of the proper density at which loose fill insulation should be applied is being studied for development of a test method.

Development of methods of tests for determining specific heat, maximum use temperature limit, and for emissivity continues in the Subcommittee on Special Thermal Properties. A new project has been inaugurated which will cover all materials of interest to the committee, namely, a method of sampling thermal insulation.

An expansion of scope of the committee has led to a new subcommittee to study protective coating materials associated with thermal insulation. The research project to determine the effect of moisture on thermal conduc-

tivity has now been started at Pennsylvania State College, underwritten by funds contributed from industry.

C-17 Asbestos-Cement Products

CURRENTLY before the committee are proposals for revision of specifications and methods of test for asbestos-cement siding shingles and clapboards, roofing shingles, and corrugated sheets. These have been carried as tentatives since 1949, and experience has indicated the desirability of testing these materials in a dry rather than in a wet state. Investigations have been made to determine new test values, and methods of test have been revised to follow the new procedure.

Studies are still under way to establish a method of test for handleability of asbestos-cement products. A subcommittee is working on the development of a method of test to determine the presence and quantities of organic matter in flat asbestos-cement sheets.

C-18 Natural Building Stones

THE preparation of specifications has presented many problems to the committee. Current consideration has been given to a proposed specification for exterior marble. The incorporation of the Tentative Method of Test for Combined Effect of Temperature Cycles and Weak Salt Solutions on Natural Building Stone (C 218) into this specification is still being questioned, and the results of a comprehensive research program being conducted at Mellon Institute by the National Association of Marble Producers are being studied with considerable interest.

The Tentative Method of Test for Durability of Slate for Roofing (C 217) is receiving further study by the slate producers before a final recommendation for changes by the committee.

C-19 Structural Sandwich Construction

SEVERAL proposed test methods on mechanical properties of basic materials which are nearing completion include core compression, core shear, core delamination, thickness, and heat distortion tests. In considering mechanical properties of basic sandwich construction, several test methods are being studied for determining peel strength. Compression and flexure of sandwich constructions are covered in proposed test methods which are about ready for committee letter ballot.

An exposure test of specimens at ASTM test sites and a fatigue test for sandwich construction or core materials are being considered. The design of an outdoor exposure test cubicle is also continuing to receive attention.

C-20 Acoustical Materials

THE first draft of a proposed method of measuring sound absorption by use of the impedance tube has been circulated for review and comment. Other methods are continuing to receive attention, including the box test method, which is essentially for obtaining laboratory check on acoustical material and for product control, and a field method of testing acoustical materials being developed by the National Bureau of Standards. The collection of data is being continued on a series of round-robin tests run in several reverberation chambers. A modification of the test method for evaluating flame resistance, as found in the Federal Specification SS-A-118a, is being checked through a series of tests for possible development of an ASTM standard. The subcommittee is also considering other proposed methods, including those of other ASTM committees.

The study of paintability and staining of acoustical materials continues to be the primary activity of the Subcommittee on Maintenance. Proposed test procedures for determining the washability of acoustical tile and the paintability of acoustical materials have been circulated for review, together with a program of investigation of staining of acoustical materials. The present activity in the Subcommittee on Application has been through a task group which is now preparing a proposed specification for adhesives for acoustical purposes. This study includes consideration of various test methods which have been proposed from various sources.

A method of light reflectance measurement based on the integrating sphere method is being prepared, which will then be submitted to Committee E-12 on Appearance for review. Procedures for strength tests are also being prepared.

C-21 Ceramic Whiteware

FIVE methods of test for clays, developed in the subsection on clays, and three tests on products developed by the subsection on fundamental properties, are in the final stages of completion as proposed tentatives. This subsection is active also in the development of test procedures for water absorption and moisture expansion.

The Subcommittee on Nomanclature is continuing its concentrated and difficult attempt to develop definitions of terms. A group of new or revised definitions is now ready for committee letter ballot, with additional definitions still under study.

The Subcommittee on Research is investigating the factors involved in obtaining comparable and reproducible values for modulus of rupture in bending, and is conducting an investigation to determine subsieve particle sizes.

C-22 Porcelain Enamel

THE section on finished products is studying nine porcelain enamel properties preparatory to developing test methods. These proposed test methods will measure abrasion, gloss thickness, thermal shock, scratching, continuity of coating, and metal marking. Seven proposed methods are being developed, chiefly concerning raw materials, which include the determination of reflectivity, coefficient of scatter, consistency of enamel slips, torsion, fusion flow, set of clay, and the evaluation of enameling iron or sagging test.

A detailed review of the glossary of terms is in process, including the preparation of a revised scope for the glossary. Thermal shock and the effect of porcelain enamel coatings on the fatigue of metals at high temperatures are receiving study by the Subcommittee on Research.

D-1 Paint, Varnish, Lacquer, and Related Products

NEWLY initiated work includes spectrographic analysis of drying oils, methods of determining iodine value of dehydrated castor oils, failure of protective coatings under accelerated light and water exposure, analysis of phthalic anhydride, abrasion resistance of floor finishes, and methods for measuring gloss of clear wood finishes.

Work is continuing on the many standing projects including the sampling of drying oils, determination of total unsaturation by hydrogenation of drying oils, humidity testing and hiding power of protective coatings, fineness characteristics of pigments, analysis of lac resins, and physical properties of glass spheres for traffic paint. New and improved equipment is now under study for determining the open-cup flash point of viscous materials.

D-3 Gaseous Fuels

PREPARATION for a method of total sulfur of gaseous fuels is under way. Further work on the Brickell method of water vapor in gas is being conducted.

D-4 Road and Paving Materials

A SURVEY has been planned on the use by State Highway Departments of test methods relating to structural properties of aggregates for the purpose of determining the significance and usefulness of these methods. The use of the penetration test for determination and limitation of temperature-susceptibility factors of bituminous materials is receiving attention and may lead to recommendations during the coming year. A new approach to the problem of measuring the degree of stripping from coated aggregates is being pursued through a cooperative investigation or several suggested methods involving techniques using radioactive tracers or flame photometry.

A survey and study of permanent type traffic markers is being initiated as the first step in a program of standardization. The incorporation of a soundness requirement for aggregate in Standard Specifications D 694 is now being considered to replace a general statement on durability. A series of cooperative tests has been outlined to obtain more fundamental data on characteristics of joint-filling materials as related to performance and specifications.

D-5 Coal and Coke

THE committee is reviewing all of its test procedures in the light of the Coke Evaluation Project Report of the American Iron and Steel Inst. and the American Coke and Coal Chemical Inst. Work presently being studied is an investigation of the Gieseler plastometer, inherent moisture under standard conditions, determination of the fusibility of ash, and studies of the Gray-King and Arnu coking tests.

Study of the new proposed international scheme for classification of coal by rank is now being undertaken.

D-6 Paper

REORGANIZATION of Committee D-6 has been accomplished with a view toward the expeditious handling and distribution of work. Development work is now under way on: paper for multiwall shipping sacks, quality control sampling paper and paper products, and permeability of paper and paper products. Revisions of Bursting Strength of Paper (D 774 – 46), Puncture and Stiffness of Paperboard, Corrugated and Solid Fiberboard (D 781 – 44 T), and Fiber Analysis of Paper and Paperboard (D 1030 – 49 T), are being studied.

New testing instruments for tensile strength and pick resistance now available to the paper industry are being evaluated by the committee for possible use in standard test methods.

D-7 Wood

CONSIDERABLE progress is expected by Committee D-7 during the coming year, particularly through research studies and tests directed toward obtaining technical information for the development and revision of standards.

The largest and most significant of the research activities relating to the work of the committee is the development and implementation of a wood pole research program sponsored by the Society under the supervision of a special task group of Committee D-7. This program is set up to provide answers to a number of vital questions concerning specifications for the procurement, design, and use of poles—questions relating to the relative strength of poles of different species, factors affecting strength, simplified methods of establishing fiber stress values for wood poles, relation of the strength of small clear specimens to that of full-sized poles and methods of testing for strength.

Tests have been under way during the past two years to obtain additional data on the effect of knots and certain other natural characteristics on the compressive strength of wood as a basis for further refinement of present ASTM Tentative Methods for Establishing Structural Grades of Lumber. It is expected that these data will be available during the coming year as a basis for some revisions of the basic principles of structural grading.

Studies are under way on the effect of rate of loading and duration of stress on the properties of structural fiberboards for consideration in connection with the establishment of loading requirements for quality control and acceptance tests. Also some studies have been under way to aid in the development of a number of additional tests required for the more complete evaluation of the properties of fiber building boards. Such other tests include nailhead pull-through, impact, impact indentation, puncture resistance, abrasion, fire resistance, dimensional stability under exposure to water vapor on one side, compression perpendicular to the faces and recovery, acoustical, properties, delamination, thermal conductivity and resistance to decay.

Features being studied in a proposed revision of the Tentative Specification for Round Timber Piles (D 25) are the limitations on short crooks, definition and limitation of sweep, and limitations of knots and knot whorls, particularly near the tip of the pile.

D-8 Bituminous Waterproofing and Roofing Materials

IN ADDITION to the development of a specification for bituminous saturated burlap fabric for use for waterproofing and roofing, Committee D-8 is also investigating the possibility of a specification covering all types of bituminous saturated fabric, regardless of the type of fiber used in the fabric. The modernization of apparatus used in the extraction of bituminous grouts and mastics is a project which is nearing completion. Data collected during the past eighteen months on the consistency of cold-applied roofing materials are now being summarized analytically for the purpose of selecting one or more methods of consistency measurement. Other properties of cold-applied materials will also be studied during the coming year.

A comprehensive program has been set up on the development of a method of test which will show whether bituminous waterproofing and roofing will crack under conditions of stress, strain, temperature, and time that are encountered in service. A task group is seeking a scientific framework for relating crack formation to these conditions and to the geometry of the sample. It is hoped that a single, scientifically sound method can be devised to permit the evaluation, through a minimum of laboratory tests, of cracking tendencies over a wide range of application and service conditions. An extensive testing program on emulsions for the purpose of re-evaluating existing tests and to develop further needed tests is now in progress.

D-9 Electrical Insulating Materials

SILICONE varnishes are receiving particular attention. Committee D-9 is preparing tests for these varnishes to test for heat stability, drying time, and chemical and oil resistance. Insulating paper test methods are being prepared to test for chlorides, acidity or alkalinity, uniformity of absorbency, bursting strength, and stretch. Specifi-

cations are also being prepared for capacitor tissues.

Other studies being conducted include dielectric strength of plastic tubing and viscous petroleum oils, determination of sludge, trace metals, and sulfur in mineral transformer oils, and dissolved or suspended water in dielectric liquids. Specifications are being prepared for silicone varnished glass fabrics and for oil in oil-packed tapes. Methods of test for polymerizable embedding materials, silicone-rubber-coated fabrics, dielectric strength of plastic tape under humid conditions, elastomeric pressure-sensitive tapes, high-temperature performance of insulating materials, and materials for internal ceramic insulators in electron tubes, are being prepared.

D-10 Shipping Containers

THREE subcommittees have been combined for the purpose of conducting a coordinated program of testing and research on factors affecting the results obtained from the standard test methods now being used in evaluating shipping containers. The three subcommittees are Subcommittee II on Methods of Testing, IV on Performance Standards, and V on Correlation of Test and Test Results. Four task groups have been organized to study the present drop test, revolving drum test, vibration test, and to develop a stacking test. The study of statistical methods is being continued.

A bibliography and abstract of cushioning studies, which relate to interior packing, is nearing completion. Check determinations are being made on a proposed load deflection method for determining energy absorption of cushioning materials. The measurement of compression set and a constant load method on cushioning materials are also under study.

D-12 Soaps and Other Detergents

Subcommittee T-1 on Soap Analysis has completed cooperative tests on a colorimetric method for determination of copper in soap. Work also is under way on the development of methods of test for the following: sulfates in soaps containing synthetic detergents; color; total P_2O_5 in soaps and synthetic detergents, by a volumetric method; chlorides in soaps and synthetics, by an electrometric method. Background data are being collected on methods for determination of carboxymethyl cellulose so that an analytical method can be established.

Subcommittee T-2 on Analysis of Synthetic Detergents has compiled a bibliography of methods for analysis of synthetic detergents, which is now available as a special technical publication. A cooperative investigation of methods for qualitative analysis of synthetics is currently under way. Data are being collected for development of a method for active organic detergents in unbuilt surfactants. A new task group has been formed to develop information on the identification and analysis of detergents by infrared spectroscopy.

Subcommittee T-4 on Analysis of Alkaline Detergents is developing methods for analysis of sodium tripolyphosphate and sodium orthosilicate.

Subcommittee T-5 on Physical Testing is preparing a revision of the Tentative Method of Test for pH of Aqueous Solutions of Soaps and Detergents (D 1172 – 51 T). A project on soil redeposition is under way, including a literature survey. A task group is reviewing several wetting test methods with the objective of possible adoption of certain of them.

Subcommittee T-6 is preparing a comprehensive guide to laboratory metal cleaning. A task group concerned with automotive industries is attempting to develop information for a classification of equipment from which specific work can proceed.

Subcommittee S-4 is engaged in development of specifications for sodium orthosilicate.

D-13 Textile Materials

A RÉSUMÉ of activity shows the following items of interest: studies of knot breaking strength of bast and leaf fibers and glass yarns are being made. Methods of twist determination of yarns, testing asbestos textiles, methods for tensile strength, moisture content, and alkali solubility of wool are being assembled. Service properties of fabrics are being investigated: namely, fire resistance, mildew and insect resistance, as well as physical and mechanical properties.

The heavy demand placed upon Committee D-13 for its cotton-yarn appearance standards has led the committee to investigate the possibility of using some means other than photographic to illustrate these appearance standards.

D-14 Adhesives

A NEW sample design for tensile strength tests is being studied. This new design is intended to replace that now found in the Method of Test for Tensile Properties of Adhesives (D 897 – 49). It will permit quicker fabrication, assembly, and mounting of specimens than was previously possible.

The Method of Test for Applied Weight per Unit Area of Dried Adhesive Solids (D 898 – 57) is under intensive critical review. Study is under way for the possible use of a tackmeter as a test method for adhesive properties.

The manufacturers of acoustical tile have evidenced much interest in a specification for adhesives in this field. In the light of this demand the committee is establishing a joint study with Committee C-20 on Acoustical Materials in an effort to satisfy this interest. Work is now completed on a new test method of electrical testing of adhesives which is being processed for proposal as tentative.

D-15 Engine Antifreezes

A PROJECT for the development of methods for determining glycols present in glycol engine antifreezes has been initiated. Projects which are under continuing study include a simple laboratory immersion test for the evaluation of the effects of antifreezes on rubber, solubility of engine antifreezes in water, and cooperative simulated service tests.

D-16 Industrial Aromatic Hydrocarbons

TEST method programs under investigation cover physical properties of naphthalene, pyridine, refined quinoline, and phenol. Bromine number determinations are being reviewed for the existing specifications for benzene, toluene, and xylene.

D-17 Naval Stores

THE committee, in collaboration with Committees E-1 on Methods of Testing and D-4 on Road and Paving Materials, is studying the possibility of a consolidation of the two ASTM Ring-and-Ball Softening Point Methods (D 36 – 26 and E 28 – 51 T) into a single ASTM standard. Investigations are being carried out on the proposed separatory funnel method for determination of unsaponifiable matter in rosin.

The committee has recently activated studies on the crystallization tendencies of rosin derivatives, which are now under way. Increased interest on the part of industry has encouraged a concerted effort to determine the possibility of obtaining further sets of the rosin color standards.

D-18 Soils for Engineering Purposes

THE committee is planning a cooperative program of testing certain

standardized soils by the direct shear method. Two types of soil will be used, one, sand, and the other, a cohesive material. This program will also include comparison with triaxial testing methods. Work is continuing on a test procedure for permeability. A symposium on this subject is planned for the 1954 Annual Meeting.

Two procedures for determining cement content of soil-cement mixtures are being studied, one being the flame photometry method and the other a chemical method. Development of a method of test for determining the California Bearing Ratio has been initiated.

Plans have been made for informal conferences or seminars on techniques and procedures for investigating the physico-chemical properties of soils. Apropriate subtopics are: (1) differential thermal analyses, (2) X-ray diffraction analyses, (3) petrographic analyses, and (4) chemical analyses.

D-19 Industrial Water

ACTIVITY in this committee on preparation of new and revised methods is continuing at an intensive pace. It is expected that four methods will be ready for submittal to the Society for publication as tentative within the coming year. These methods will cover the following tests: oily matter in industrial waste water, dissolved and suspended solids (matter) in industrial water and industrial waste water, sampling of water and steam at subatmospheric pressure (to be included in the Tentative Methods of Sampling Steam (D 1066 – 49 T), and toxicity to aquatic life of industrial waste water.

It is expected that revisions of the following seven methods will be submitted for publication within the coming year: Test for Total Carbon Dioxide and Calculation of the Carbonate and Bicarbonate Ions in Industrial Water (D 513 – 50 T), Test for Hydroxide Ion in Industrial Water (D 514 – 47), Test for Sulfate Ion in Industrial Water (D 516 – 49), Test for Nitrate Ion in Industrial Water (D 992 – 52), Test for Total Orthophosphate and Calculation of the Respective Orthophosphate Ions in Industrial Water (D 515 – 43), Tests for Dissolved Oxygen in Industrial Water (D 888 – 49 T), and Tests for Acidity and Alkalinity in Industrial Water (D 1067 – 51 T). Revisions of the first six methods will cover nonreferee procedures suitable for inclusion in the power boiler test code of The American Society of Mechanical Engineers. The revision of Method D 888 will also include extensive revisions of the present referee and nonreferee methods, in preparation for which it is expected that another clinic will be held to study the dissolved oxygen tests, somewhat similar to the clinic held on this same subject at Baltimore, in July, 1952. The revision of Method D 1067 will make this method applicable to industrial waste water as well as to other industrial water.

Thirty-six new or revised methods and specifications are already under study, except for a few cases in which work will be started within the coming year. Of the new and revised methods now under study, methods for the following twelve determinations are intended to apply specifically to industrial waste water: phenolic compounds, cyanide, specific gravity, mercaptans, biological oxygen demand, low concentrations of chemical oxygen demand, silica, infrared determination of oil, nitrogen-base compounds, taste, chromate compounds and chromium, and radioactivity. Procedures for sampling and gaging industrial waste water are also under study.

The following 21 new methods and revisions of existing methods are also under study: identification of algae, fluoride, chloroform, extractable matter, hardness, optical properties, iodide and bromide, ammonia, organic matter, copper, hydrogen, sulfides, sulfite, surface tension, oxidation reduction potential, chemical analysis of water-formed deposits, non-destructive procedure (using Turner Test Gage) for measurement of thickness of deposits, service tests of metallic tubular products, polarographic test procedures, flame photometry procedures, and emission spectroscopy procedures. A revised method of reporting analysis of industrial water and industrial waste water is being studied. Consideration is also being given to revision of the Tentative Specifications for Reagent Water (D 1193 – 52 T).

D-20 Plastics

NEW projects established by Committee D-20 include comparative studies of the British Admiralty hardness test with comparable ASTM hardness tests, methods for evaluating scratch resistance, and specifications for modified polystyrene plastics. Projects which are being brought to conclusion are a method for determining the heat stability of plasticizers and three methods of testing the total chlorine, volatile content, and the particle size, of vinyl chloride polymers.

Continuing work is being accomplished on the measurement of the dynamic properties of plastics, methods for the flammability, distortion by heat, and brittle temperature of plastics, and specifications for modified polystyrene plastics.

The committee is looking into the desirability of preparing specifications for plastic pipe and also standards applying to the testing of pyroxylin and vinyl resin coated fabrics.

D-21 Wax Polishes

Subcommittee V on Specifications has been appointed a small task group to prepare a specification on general-purpose floor waxes which will not necessarily be more than a framework at this time, to be filled in with proper requirements and test method references as they are developed. The subcommittee has now completed its review of descriptions of the various properties of floor waxes, which should be included in a specification. The other subcommittees concerned with test methods have been developing standard procedures in line with these significant properties.

Subcommittee I on Nomenclature is preparing a glossary which will include such terms as soil retention, soil acceptance, scuff, mar, water spotting, leveling and spreading. One important definition being developed is that for the term "water emulsion waxes."

Subcommittee II on Raw Materials has made editorial revisions in two proposed methods, which will be first published as information only in the ASTM BULLETIN. These methods will cover refractive index and a procedure for concentrating additives in carnauba or other vegetable waxes.

Subcommittee III on Chemical and Physical Testing reported work on proposed methods for determining pH, free alkali, refractive index, and flash point. Decision was made to drop further consideration of the use of a revision of ASTM Method for Determining Kinematic Viscosity (D 445). In this connection a new task group was authorized to study stability in terms of storage life, and the matter of a simpler test for determining kinematic viscosity will be included in this new study.

Subcommittee IV on Performance Tests continues to receive the interest of the members in its efforts to develop standard methods of measuring performance in terms of slip resistance, appearance, and service life. Two methods for measuring coefficient of friction of floor surfaces, dynamic and static, respectively, and more commonly known as the Sigler and James types, will now be rewritten and prepared for publication information only. In addition, round-robin tests will be run to establish the use of a ground-glass plate as a secondary

standard for use in connection with the leather heel used in the testing procedure.

The Section on Service Life is now preparing a draft of a water spotting test method which will be submitted to the subcommittee for letter ballot. The round-robin tests using three unknown waxes gave very uniform results for this proposed method.

D-22 Atmospheric Sampling and Analysis

ONE of the first activities of this committee was the preparation of definitions. Some 75 terms were listed as requiring definition at this time and some 60 other suggested terms were placed on a deferred list. Tentative definitions have been developed for some 20 terms and considerable progress has been made on the balance.

Three drafts of possible future standards are currently being considered: one on general principles of sampling, one on gases and vapors, and the third on stack or effluent sampling. A tentative draft on miscellaneous sampling is currently being revised.

The odor study group has developed two methods for the determination of odor, one a dilution method and the other employing activated carbon absorption and identification of pollutants by analysis. The fluoride study group is studying certain factors in connection with titration employing alizarin and thorium nitrate. Consideration is being given to the use of alpha-naphthylamine and phenol-disulfonic acid methods for the determination of oxides of nitrogen.

A report on the sulfur dioxide analyzer is currently under consideration, by the Subcommittee on Instrumentation. Other methods being considered are spot methods for dirt, directional dust fall collection, and an oxidant recorder.

D-23 Cellulose

A REPORT of the work of the newly formed Committee D-23 on Cellulose shows concerted activity to develop much needed test procedures in this field. Tentative procedures to be presented in the near future are: viscosities of cellulose derivatives by the Ball-Drop Method, moisture content of cellulose materials, and methods of testing methyl cellulose. Revised versions of existing standards to be presented are: Specifications and Tests for Soluble Nitrocellulose (D 301) and Standard Methods of Testing Cellulose Acetate (D 871).

The committee work now in progress includes: a survey of methods of absorption and color of cellulose and derivatives methods for alpha, beta, and gamma-cellulose, ash constituents of cellulose, disperse viscosity by use of standard solvents, methods for cellulosic extractives, test methods for pentosans, and molecular chain length of cellulose and its derivatives. Test procedures for other organic and inorganic esters of cellulose are currently being surveyed. Methods of analyzing sodium carboxymethylcellulose are being studied in an effort to decide upon those best suited for proposal as standard.

A new Subcommittee on Statistics has been organized and will be particularly concerned with inter-laboratory checking, interpretation of data, and presentation of resulting information.

E-1 Methods of Testing

PREPARATION of a test method for the determination of Young's modulus for metals at room temperature is under way, and will be followed by methods for the determination of Poisson's ratio, and the shear modulus. Consideration is being given to the use of balances and weights for the calibration of hardness testing machines.

Considerable work is being accomplished in refining existing standards and in the introduction of specifications for specialized thermometers.

E-2 Emission Spectroscopy

WITH the book, "Methods for Emission Spectroscopy," soon to be published the committee is continuing the collection of suggested methods, with the thought that some may provide the basis for new tentative methods, while others may be included in subsequent editions of the book. A task group on flame photometry has been established to collect information on this technique.

Having already assembled more than 50 suggested methods and having written the new Tentative Methods for Spectrochemical Analysis of Zinc-Base Alloys and High-Grade Zinc by the Solution - d-c Arc Technique (E 26 – 53 T) and Aluminum and Aluminum-Base Alloys by the Point-to-Plane Spark Technique (E 101 – 53 T), Committee E-2 is turning a major portion of its efforts to the preparation of the following items for publication in the form of tentatives: recommended practices for installation and safe operation of the spectrochemical laboratory (based on suggested method E-2 SM 1-1); method for spectrochemical analysis of nickel alloys by the dry powder - d-c arc technique (based on E-2 SM 5-1); method for analysis of tin-base alloys by the dry powder - d-c arc technique (based on E-2 SM 6-4); method for spectrochemical analysis of copper alloys by the point-to-plane spark technique (based on E-2 SM 5-9); additional methods for spectrochemical analysis of aluminum and its alloys; methods for spectrochemical analysis of zinc; and methods for spectrochemical analysis of iron and steel. It is expected that several of these proposed tentatives will be completed within the coming year.

E-3 Chemical Analysis of Metals

DIVISION F on Ferrous Metals has substantially completed preparation of methods for chemical analysis of ferroboron, ferrotitanium, and ferrotungsten, and a photometric method for determination of manganese in steel. Also under development are methods for the following: analysis of high-silicon steel; aluminum, columbium, and tantalum in stainless-type steels; magnesium in nodular iron; cobalt in high-alloy steels; sulfur (combustion) in plain carbon steels and cast iron; and zirconium in alloy steels. The high-frequency inductance combustion method for sulfur is being studied. The division intends to explore intensively the possibilities of photometric methods for small or residual amounts of elements in steel and iron.

Division N on Non-Ferrous Metals has nearly completed methods for the analysis of berylium-copper alloys. A joint task group with Committee B-4 on proposed tentative methods for the analysis of electronic nickel has prepared a set of revised procedures for copper, iron, manganese, titanium, and cobalt which are being cooperatively tested and are expected soon to be ready for committee letter ballot. Work is also under way on new or revised methods for the following: analysis of fire-refined copper; analysis of aluminum for magnesium, silicon, and zinc by photometric methods; determination of aluminum, copper, and lead in zinc by photometric methods; analysis of silver solder; determination of aluminum, silicon, magnesium, and sulfur in electronic nickel; and determination of zirconium in magnesium-base alloys. A number of the above methods are expected to be ready for inclusion in the next edition of the book of ASTM Methods for Chemical Analysis of Metals, now planned for publication late in 1954.

Division M on Miscellaneous Metals is developing methods for the analysis of titanium. Cooperative work is being carried on with interested groups outside

of the Society on methods for nitrogen, chromium, carbon, vanadium, and manganese.

Division S on Sampling is considering a possible combination of the Method of Sampling Wrought Non-Ferrous Metals and Alloys for Determination of Chemical Composition (E 55 – 48) and the Tentative Methods of Sampling Non-Ferrous Metals and Alloys in Cast Form for Determination of Chemical Composition (E 88 – 50 T). A task group is starting work on sampling methods for titanium metals and alloys.

Division G on General Analytical Methods is continuing work on performance standards for analytical balances, and exploratory work is being done on performance standards for photometers and for electrolytic apparatus. A "common procedure" for the determination of nickel that can be adapted to various metals with only slight modifications is being developed. A "common procedure" for manganese by the periodate method also is being prepared.

E-5 Fire Tests of Materials

Good progress is being made in the preparation of a proposed tentative method of test which will be used in defining "noncombustibility" as applied to building materials. This method will provide technical and scientific knowledge of the combustibility of homogeneous materials having very low ranges of combustibility and of such nature that they can be tested by this method. Several drafts of a proposed test method for establishing the fire hazard of roof coverings have been prepared, and certain features pertaining to materials and their method of application are under discussion with representatives of the roofing industry. Revisions are being discussed by the subcommittee of the ASTM Standard Method of Fire Test (E 119), one revision having to do with the conditioning of specimens, particularly as to the requirements for artificial drying. This study also involves the definition of the term "combustible."

A research test program at Forest Products Laboratory, temporarily discontinued, has now been reinstituted through the efforts of the committee in obtaining support from industry. This program is for the purpose of developing smaller-scale tunnel type fire testing equipment than that referred to in ASTM Tentative E 84 T.

Correction in Society Letter Ballot on Standards

As this issue of the ASTM Bulletin goes to press, the letter ballot on the approval of actions with respect to standards taken at the Annual Meeting is being canvassed. Attention is called to an error that appeared in this ballot, namely, that the specific action called for in the adoption of tentative revisions of Standard Specifications for Masonry Cement (C 91 – 52) was incorrectly stated (Item 19*b*). Committee C-1 had recommended the adoption as standard of the current tentative revision of Specifications C 91 which had to do with the revision of Section 7 (see annual report of Committee C-1), whereas the ballot (and the Summary of Proceedings) erroneously referred to certain revisions being adopted that had just been recommended by Committee C-1 for publication as tentative. This error may have led to some misunderstanding on the part of members voting the ballot and if there has been any misunderstanding, members may wish to change their vote.

E-12 Appearance

Current activites are centered about color difference and gloss measuring devices. In the former activity, the committee is evaluating the instruments which are presently available for color difference measurements. The latter activity is being explored in an effort to consolidate the several existing techniques for measuring gloss into one goniophotometric procedure flexible enough to be used in all gloss problems.

Ideal Cement Company Dedicates New Research Center

In dedicating the new laboratory and research center of the Ideal Cement Co., at Boettcher, Colo., the President, Cris Dobbins, called attention to the very constructive work of those in the company responsible for research. A number of the Ideal Cement personnel are members of ASTM, and follow many phases of the Society's work.

The new laboratory will concentrate on basic research, specifically on those subjects where insufficient information exists, and largely problems which are unique to the company plants and sales areas.

NEW ASTM PUBLICATIONS

Mass Spectrometer Analysis of Solids Discussed in New Symposium

ASTM Committee E-2 on Emission Spectroscopy has made a practice of sponsoring symposiums from time to time with particular emphasis on instrumental analysis. The Symposium on Chemical Analysis of Inorganic Solids by Means of the Mass Spectrometer was one such symposium, held at a meeting of the committee during the Society's 1951 Annual Meeting. This group of papers has now been published as *ASTM Special Technical Publication No. 149*.

As stated in the Foreword by B. F. Scribner, chairman of Committee E-2, this symposium "departs somewhat from past practice in that it involves a different field of spectroscopy but one that offers promise as a means of parallel analysis of the materials now being analyzed by optical spectroscopy. This new application of mass spectrometry may employ some of the techniques of optical spectroscopy, including the use of the spark to volatilize substances, and it undoubtedly is faced with some of the ever-present problems, including sampling."

Future work in this field will be carried forward by the recently organized ASTM Committee E-14 on Mass Spectrometry.

Titles and authors of the papers are as follows:

The Mass Spectrometer as a Tool for the Determination of Trace Element Impurities in Solid Samples—Mark G. Inghram

Mass Spectrometric Analysis of Solids with the High-Frequency Spark—J. A. Hipple and J. G. Gorman

Mass Spectrometric Analysis of Copper for Cuprous-Oxide Rectifiers—W. M. Hickam

The complete publication, including individual bibliographies for each of the papers, and a general discussion, can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. for $1.25; to members, $1.00.

Technical Papers Published

IT IS planned to include in each issue of the ASTM BULLETIN a list of the technical papers which have recently appeared.

These lists largely comprise papers contained in the newer Special Technical Publications although some of them are advance printing of individual papers that are to appear in the *Proceedings*.

Symposium on Plastics Testing —Present and Future

The Management and Significance of the Mechanical Strength Properties of Plastics by C. H. Adams, Monsanto Chemical Co.

Measurement of the Effect of Temperature on Some Physical Properties of Plastics by J. P. Tordella, A. C. Webber, and E. B. Cooper, E. I. du Pont de Nemours & Co.

Measurement of Color, Gloss, and Haze by Harry K. Hammond, III, National Bureau of Standards, and George W. Ingle, Monsanto Chemical Co.

The Effects of Molding Conditions upon the Permanence of Plastics by J. L. Williams and J. W. Mighton, The Dow Chemical Co.

Residual Stresses in Phenolic Plastics by L. E. Welch, Engineer, and H. M. Quackenbos, Jr., Bakelite Co.

Fretting Corrosion Investigated in New Symposium

IN A dual effort to present the latest work of experts in the field to as wide an audience as possible, and to stimulate future investigative activity on the subject, ASTM Committee D-2 on Petroleum Products and Lubricants held a Symposium on Fretting Corrosion at the 50th Anniversary Meeting of the Society in 1952.

The papers and discussion comprising the symposium, which was sponsored by D-2's Technical Committee G on Grease, have now been published as *ASTM Special Technical Publication No. 144*.

Sometimes called "friction oxidation," "wear oxidation," "false brinelling," or "chafing," fretting corrosion is defined by T. E. De Villiers in the Introduction to the published symposium as "a surface damage that occurs when two solid surfaces are contacted under relatively high loads and with small relative (vibratory) motions."

Titles of the papers and their authors are as follows:

Introduction—T. E. De Villiers

The Current Status of Fretting Corrosion—W. E. Campbell

Fretting Corrosion Tendencies of Several Combinations of Materials—J. R. McDowell

Influence of Fretting Corrosion on the Fatigue Strength of Fitted Members—O. J. Horger

Effect of Lubricants in Minimizing Fretting Corrosion—E. W. Herbek, Jr., and R. F. Strohecker

Test Equipment for Evaluating Fretting Corrosion—H. H. Uhlig, W. D. Tierney, and A. McClellan.

The complete symposium, with discussions, can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia, Pa. for $2.75; price to members is $2.00.

1953 ASTM Year Book

THE 1953 Year Book of the Society will soon be distributed to members who have requested a copy.

A comprehensive reference book of ASTM personnel and fields of activity, the 600-page book contains an alphabetic list of members with addresses, titles, and company affiliations of each individual, and, in the case of company memberships, the name of the company representative.

Approximately half the book is devoted to a listing of committee personnel. This section lists all technical committees and other committees, their officers, and the complete personnel of the main committees and subgroups.

Other portions of the Year Book are devoted to the By-laws and Charter of

the ASTM, its regulations, lists of award winners, information on various administrative committees, and District Councils. Also bound into each copy are membership application blanks for ready availability to members when a new membership is in prospect.

This book is distributed to members on request and many have asked that they be included on the permanent mailing list. A copy is given to each new member who also has the privilege of having his name placed on the permanent mailing list.

The Year Book is not available for general distribution; it is published only for use of the members in connection with the activities of the Society.

Anniversary Publication—Fifty Years of Paint Testing

COMMITTEE D-1 on Paint, Varnish, Lacquer, and Related Products marked its own 50th birthday in the midst of the Society's 50th Anniversary meeting in 1952 with a special session and other events celebrating a half century of steadily expanding usefulness.

In "Fifty Years of Paint Testing," just off press, are published the papers presented at this special session. These papers, as a whole, were designed to represent an inventory of the paint testing field, and to provide a reference point for future work.

Prepared by the respective subcommittee chairmen, the papers review and evaluate the accomplishments of the past but stress the purposes and directions of research and development, staking out unexplored territory and, in some cases, predicting developments that can be expected in the future.

Materials covered in the 16 reports are drying oils, bituminous emulsions, hydrocarbon solvents, varnish, resins, shellac, printing inks, and cellulosic coatings. Also included are wood exposure and accelerated tests, chemical analysis methods, and pigment specifications; physical and optical properties, and flash point; and protection of iron and steel.

Copies of this anniversary publication, *ASTM Special Technical Publication No. 147*, can be obtained from ASTM Headquarters for $1.25; price to members is $1.00.

ASTM Joins ASME in Sponsoring Railway Steel Wheel Symposium

At the recommendation of Committee A-1 on Steel, the Society will sponsor jointly with the Railroad Division of The American Society of Mechanical Engineers, a Symposium on Railway Steel Wheels which will be held December 3 as part of the ASME Annual Meeting in Chicago.

Through E. M. Van Winkle, Chairman of the ASME Committee on Meetings and Papers, announcement has been made of the following program for the morning session:

Wrought Steel Passenger Car Wheels from a Consumer's Standpoint by A. M. Johnsen

Measurement of Stresses Imposed on Wheels in Diesel Locomotive Service by L. L. Olson

Wheel Performance with Disc Brakes by Paul V. Garin

Wheel Defects in Equipment with Clasp Brakes by S. M. Riegel

Railroading Today Through the Eyes of the Wheel Manufacturers by Charles B. Bryant

Included in the afternoon session are:

Pressure Pouring Steel Car Wheels in Permanent Molds by E. Q. Sylvester

1.5% Carbon Cast Steel Railroad Car Wheels by N. A. Matthews

The Use of Steel Wheels in Freight Service by Bruce C. Gunnell

Chairman and Vice Chairman respectively, of the morning session, are O. J. Horger, Timken Roller Bearing Co., and Clarence Pond, Norfolk and Western Railway; afternoon session, F. A. Benger, Canadian Pacific Railway, and J. W. Hawthorne, Atlantic Coast Line Railroad.

A number of the authors and participants in the symposium are active in ASTM committee work.

Thermal Insulation Society

A NEW society in the technical field which shows signs of rapid growth, is the Thermal Insulation Society, organized about four years ago in Charleston, W. Va., under the leadership of Ray Thomas, long an active member and officer of ASTM Committee C-16 on Thermal Insulating Materials.

The new society has been organized to accumulate, record, and disseminate information to those interested in thermal insulation and its problems; to coordinate the study and solution of problems and provide a medium of exchange of ideas between those engaged in the various phases of work with thermal insulation materials; to promote cooperation with other organizations engaged in the technical and physical development of the product and improvement of these materials; to endeavor at all times to advance the science of thermal insulation and increase the knowledge thereof.

Its membership will include general design engineers, plant engineers, and those responsible for field application of thermal insulation materials. Through the medium of speakers representing various material producers, it is hoped to supply the membership with better all-around knowledge and appreciation of materials for which they are responsible. Programs will also be provided with the sole purpose of presenting problems by the field forces for general consideration and discussion.

Four chapters are now operating in Charleston, W. Va., Pittsburgh and Philadelphia, Pa., and Houston, Tex. With the addition of a fifth chapter in the near future, organization will be completed. Ray Thomas was formerly associated with Union Carbide and Carbon Corp. and is now Executive Vice-President of the Vimasco Corp., Nitro, W. Va.

Pittsburgh Diffraction Conference

THE Eleventh Annual Pittsburgh Diffraction Conference will be held at Mellon Institute, Pittsburgh, Pa., on November 5 and 6, 1953. Technical sessions are being arranged on Instrumentation and Methods, Metals, Recrystallization and Preferred Orientation, and Structure of Polymers. Papers on general diffraction subjects will also be accepted.

For further information, and for a copy of the preliminary program when available, write to H. R. Letner, Mellon Institute, Pittsburgh 13, Pa.

ASTM Bulletin

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NINETEEN-SIXTEEN
RACE STREET
PHILADELPHIA 3, PENNA.

The Responsibilities of ASTM and of Industry

WHILE reviewing the annual reports of some of the companies whose stocks are in ASTM's investment portfolio, we made some comparisons which dramatize the vastness of our industrial economy and the civic responsibilities this imposes.

In 1952 American Telephone and Telegraph Co. spent $3½ billion and employed nearly 700,000 people. In the same year, General Motors spent over $7 billion and employed 450,000. For comparison, consider that prior to 1935, total United States Treasury annual expenditures (including interest on public debt) were less than $7 billion except in the war years 1918 and 1919; and prior to 1934, Federal employees numbered less than 700,000, again excepting the World War I years.

Behind this huge expenditure and employment are the stockholders who have invested their savings in our industrial corporations. In the case of A.T.&T., there are nearly 1¼ million stockholders. What has been said of these two companies applies to a somewhat smaller extent to many other companies.

We believe that these figures show that the public are our industrial corporations and that our industrial corporations are the public. The economic health of the nation is that of our corporations. Their interests are mutual. Exemplifying management's recognition of this are the following remarks of the chairman of the board of one of our largest oil companies:

"In the meanwhile, the new Administration is deserving of patience and cooperation from everyone, business men in particular. If on the contrary the latter, with a long-sought business type of administration in office, place their own selfish interests ahead of the country's, they can look forward to little help from this or future administrations and will deserve less. We are confident that what is best for the country as a whole is bound to be good for our company."

Since we in ASTM serve industry and many of us are employees of industrial corporations, some measure of this broad responsibility falls on us.

A glance at our Year Book will reveal that many of our members are presidents and vice-presidents of industrial organizations. There are many past members whose executive responsibilities are now so great that they cannot actively and directly participate in our work. The pace and complexity of our technological progress demand more and more executives with scientific training. This is a challenge. These responsibilities demand more than just technology as was revealed last year at the Yale Centennial of Engineering where the general theme of the meeting was the engineer's need to broaden himself. How to be a good engineer and at the same time acquire skills in business, public relations, and the humanities poses quite a problem. It sounds like a lot of midnight oil.

L. B. Beard Jr.

President, ASTM

Schedule of ASTM Meetings

This gives the latest information available at ASTM Headquarters. Direct mail notices of all district and committee meetings customarily distributed by the officers of the respective groups should be the final source of information on dates and locations of meetings. This schedule does not attempt to list all meetings of smaller sections and subgroups

DATE	GROUP	PLACE
Oct. 1–2	Committee B-1 on Wires for Electrical Conductors	ASTM Headquarters, Philadelphia, Pa.
Oct. 6–7	Committee B-5 on Copper and Copper Alloys	ASTM Headquarters, Philadelphia, Pa.
Oct. 7–9	Committee D-15 on Engine Antifreezes	Cincinnati, Ohio
Oct. 8	New England District Meeting	Cambridge, Mass.
Oct. 8	Committee C-14 on Glass and Glass Products	Rochester, N. Y.
Oct. 8–9	Committee B-4 on Electrical Heating, Resistance, and Related Alloys	Washington, D. C.
Oct. 8–9	Committee C-19 on Structural Sandwich Constructions	ASTM Headquarters, Philadelphia, Pa.
Oct. 13–15	Committee B-8 on Electrodeposited Metallic Coatings	ASTM Headquarters, Philadelphia, Pa.
Oct. 14–16	Committee D-13 on Textiles	New York, N. Y.
Oct. 14–16	Committee D-14 on Adhesives	Wyandotte, Mich.
Oct. 15	Joint St. Louis District-ASM Meeting	St. Louis, Mo.
Oct. 19–21	Committee C-1 on Cement	Lafayette, Ind.
Oct. 20	New York District Meeting	New York, N. Y.
Oct. 21–23	Committee C-9 on Concrete and Concrete Aggregates	Lafayette, Ind.
Oct. 22–23	Committee D-10 on Shipping Containers	Boston, Mass.
Oct. 26–28	Committee C-16 on Thermal Insulating Materials	Williamsburg, Va.
Oct. 27	Joint Pittsburgh District-SAE Meeting	Pittsburgh, Pa.
Oct. 27–28	Committee C-22 on Porcelain Enamel	Middletown, Ohio
Feb. 1–5	**ASTM Committee Week**	**Washington, D. C.**
June 14–18 1954	**ASTM Annual Meeting—Apparatus and Photographic Exhibit**	**Chicago, Ill.**

Personnel of Board of Directors and Committees of the Board

SUBSEQUENT to the June election of five new members to the Board of Directors of the Society, the Executive Committee of the Board and the other Board Committees provided for under the By-Laws, were reorganized.

The personnel of the new Executive Committee which will function during 1953–1954, and of the other seven subcommittees appears below.

ASTM Board of Directors

President:

L. C. BEARD, JR., Assistant Director, Socony-Vacuum Labs., Socony-Vacuum Oil Co., Inc., 26 Broadway, New York 4, N. Y.

Vice-Presidents:

N. L. MOCHEL, Manager, Metallurgical Engineering, Westinghouse Electric Corp., Lester Branch Post Office, Philadelphia 13, Pa.

C. H. FELLOWS, Director, Engineering Lab. and Research Dept., The Detroit Edison Co., 2000 Second Ave., Detroit 26, Mich.

Directors:

(Term Expiring in 1954)

J. W. BOLTON, Director of Metallurgical Research and Testing, The Lunkenheimer Co., Beekman and Waverly Sts., Cincinnati 14, Ohio.

R. A. SCHATZEL, Vice-President and Director of Engineering, Rome Cable Corp., 330 Ridge St., Rome, N. Y.

E. O. SLATER, President and Manager, Smith-Emery Co., 920 Santee St., Los Angeles 15, Calif.

STANTON WALKER, Director of Engineering, National Sand and Gravel Assn., 1325 E Street, N. W., Washington 4, D. C.

F. P. ZIMMERLI, Chief Engineer, Barnes-Gibson-Raymond, Division of Associated Spring Corp., Box 555, Plymouth, Mich.

(Term Expiring in 1955)

G. R. GOHN, Supervisor, Creep and Fatigue Labs., Bell Telephone Laboratories, Inc., 463 West St., New York 14, N. Y.

W. H. LUTZ, Technical Director, Pratt & Lambert, Inc., 79 Tonawanda St., Buffalo 7, N. Y.

H. K. NASON, Research Director, Organic Chemicals Div., Monsanto Chemical Co., 800 N. 12th Blvd., St. Louis 1, Mo.

A. O. SCHAEFER, Vice-President in Charge of Engineering and Manufacturing, The Midvale Co., Nicetown, Philadelphia 40, Pa.

M. A. SWAYZE, Director of Research, Lone Star Cement Corp., 15th Floor, 100 Park Ave., New York 17, N. Y.

(Term Expiring in 1956)

N. A. FOWLER, Director of Sales and Research, General Box Co., 1825 Miner St., Des Plaines, Ill.

R. T. KROPF, Vice-President, Industrial Thread Div., Belding Heminway Corticelli, 1407 Broadway, New York 18, N. Y.

T. F. OLT, Director, Research Labs., Armco Steel Corp., Middletown, Ohio.

J. R. TOWNSEND, Director, Material and Standards Engineering, Sandia Corp., Sandia Base, Albuquerque, N. Mex.

K. B. WOODS, Associate Director, Joint Highway Research Project and Professor of Highway Engineering, Civil Engineering Bldg., Purdue University, Lafayette, Ind.

Past-Presidents:

L. J. MARKWARDT, Assistant Director, U. S. Forest Products Laboratory, Madison 5, Wis.

T. S. FULLER, Consultant, 2131 Grand Blvd., Schenectady 9, N. Y.

H. L. MAXWELL, Technical Adviser, Engineering Dept., E. I. du Pont de Nemours and Co., Inc., 1350 Louviers Bldg., Wilmington 98, Del.

Committees of Board of Directors

Executive Committee

N. L. Mochel, *Chairman*

L. C. Beard, Jr. — H. L. Maxwell
W. H. Lutz — T. F. Olt
Stanton Walker

Meetings and Programs

F. P. Zimmerli, *Chairman*

N. A. Fowler — E. O. Slater
R. T. Kropf — J. R. Townsend

Finance Committee

L. J. Markwardt, *Chairman*

T. S. Fuller — N. L. Mochel
H. L. Maxwell — R. A. Schatzel

Technical Committee Activities

H. K. Nason, *Chairman*

G. R. Gohn — R. A. Schatzel
T. F. Olt — J. R. Townsend

Membership Committee

M. A. Swayze, *Chairman*

C. H. Fellows — K. B. Woods
A. O. Schaefer — F. P. Zimmerli

Inter-Society Relations

A. O. Schaefer, *Chairman*

C. H. Fellows — Stanton Walker
W. H. Lutz — K. B. Woods

Developmental Activities

J. W. Bolton, *Chairman*

N. A. Fowler — H. K. Nason
R. T. Kropf — E. O. Slater

Lectures and Awards

G. R. Gohn, *Chairman*

J. W. Bolton — T. F. Olt
W. H. Lutz — M. A. Swayze

President Beard is an *ex-officio* member of all Board Committees.

To ASTM Nonmembers: The Society welcomes inquiries on the "Advantages of Membership"

To the ASTM Committee on Membership
1916 Race St., Philadelphia 3, Pa.

Gentlemen:

Please send me information on Membership in ASTM and include a membership application blank.

Signed_____

Address_____

Date_____

Districts Planning Fall and Winter Meetings

President Beard and Dr. Rossini Featured on Several Programs

TWELVE ASTM district meetings have already been scheduled for the Fall and Winter and many more are in the planning stage. The highlight of a number of these meetings will be an address by President L. C. Beard, Jr., who will speak on the use of additives in petroleum products, the title of his talk being "Something Has Been Added." Dr. Beard has already made commitments to speak before the New York, Pittsburgh, and Philadelphia Districts on October 20, October 27, and January 20, respectively. The Pittsburgh meeting will be a joint meeting with the SAE and the Philadelphia meeting will be held in conjunction with a meeting of the American Chemical Society in Wilmington, Del. He will also address the Ohio Valley District at a meeting to be held in Indianapolis during the first week of November.

Dr. Beard and Executive Secretary Painter are planning to make a trip through the West and Southwest sometime the latter part of February and at that time the President will address the Northern California, Southern California, St. Louis, and Southwest Districts and will probably also speak at Richland, Wash.

The 1953 Marburg Lecturer, Dr. Frederick D. Rossini, is also preparing for a series of talks based on his lecture entitled, "An Excursion in Petroleum Chemistry." Dr. Rossini will speak before the Northern California District in San Francisco on November 12, the Southern California District in Los Angeles on November 13, and before the Southwest District in Houston on November 20. The Southern California meeting is a joint meeting with the American Chemical Society and the Southwest meeting will include ASTM, American Institute of Chemical Engineers, American Chemical Society, and American Society for Quality Control. Dr. Rossini's subject, although on the subject of petroleum, is entirely different from that of Dr. Beard. Dr. Rossini's talk deals essentially with the history of petroleum and the intensive research responsible for our greatly enhanced knowledge of the fundamental composition of petroleum and for the many pure hydrocarbons which have been isolated.

Other meetings scheduled are a Philadelphia meeting to be held jointly with the National Association of Corrosion Engineers on September 18, at which time C. L. Bulow will discuss "Copper and Copper Alloys." Dr. John Sterner of Baird Associates will speak on trace chemistry before the New England District on October 8. C. R. Gillette of the New Departure Division of General Motors Corp. will address the New York group on November 18 on the subject of "Rust Prevention Practices and Manufacturing Operations." This will be a joint meeting with the American Society of Lubricating Engineers. The New York District has also planned a meeting for January 28 with the American Society of Mechanical Engineers at which time Louis Eckelmann, Pyrene Mfg. Co., will talk on "Metal Finishing."

The New England Spring meeting is scheduled for April 22 in Storrs, Conn. This will be held at the University of Connecticut and a special effort will be made to arouse student interest. President Beard will be on the program for this meeting. Although the above meetings are subject to change, it is hoped for the most part that the dates noted will hold. There, of course, will be a number of additions, as many of the councils have yet to hold their late Summer or Fall meetings.

Oak Ridge Announces Winter Radioisotope School

INDUSTRIAL research scientists may apply for admission to the winter series of courses in the techniques of using radioisotopes in research at Oak Ridge, Tenn. Starting dates of the next three courses are January 4, February 8, and March 15, 1954. Applications must be received *three months* in advance of the starting date.

The 4-week courses are offered to enable mature research personnel to obtain sufficient facility in the use of radioisotopes to apply them to their own research problems. Since the demand for this training exceeds the facilities for supplying it, the course is designed for university faculty members, research group leaders, and others who will impart the training to additional persons.

Participants are selected by a committee representing the Institute and the Isotopes Division and Oak Ridge Operations Office of the Atomic Energy Commission.

Applications and additional information may be obtained from the Special Training Division, Oak Ridge Institute of Nuclear Studies, P. O. Box 117, Oak Ridge, Tenn.

To ASTM Members: Your help is needed in maintaining that constant increase in ASTM Membership

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To the ASTM Committee on Membership,
1916 Race St., Philadelphia, 3, Pa.

Gentlemen:

Please send information on membership to the company or individual indicated below:

_____

_____

This company or individual is interested in the following subjects: indicate field of activity, that is, petroleum, steels, non-ferrous, etc.

_____

Signed _____

Date _____ **Address** _____

Government-Owned Inventions Available for License

To encourage industry, particularly smaller plants, to take advantage of the fruits of Government-financed research, the U. S. Department of Commerce, in cooperation with the Government Patents Board, has made available in practical form information relating to 3658 Government-owned patents.

This information has been published by the Department of Commerce so that greater productive use might be made of the scientific and technological advances brought about at Government expense.

The book supersedes the 1951 "Government-Owned Inventions for Free Use" which has been completely reorganized, brought up to date and made easier and more practical to use. Copies can be obtained from the Government Printing Office, Washington, D. C., or at field offices of the Department of Commerce for $1.

International Conference on the Science and Applications of Photography

THE Royal Photographic Society of Great Britain will celebrate its centenary throughout 1953 and is holding an International Conference on the Science and Applications of Photography, in London, from September 19 to September 25.

The Conference will cover many aspects of the science, technique, and applications of photography and will be divided into five sections dealing with the following topics: (*a*) Photographic Science (including the theory or latent image and development, sensitization, sensitometry, resolving power, granularity, and the properties of photographic materials); (*b*) Kinematography and Color Photography; (*c*) Technique and Applications of Photography (including industrial radiography, photomicrography, spectroscopy, aerial photography, photogrammetry, high-speed photography, nuclear track recording, and other physical, chemical and biological applications; photocopying; apparatus, processes, manipulations); (*d*) Photomechanical Processes; and (*e*) History, Literature (including abstracting and documentation, and training in photography).

All communications regarding the Conference should be addressed to Dr. R. S. Schultze, A.R.P.S., Honorary Secretary, R.P.S., Centenary Conference, 16 Princes Gate, London, S. W. 7.

Technical Committee Chairmen and Secretaries

LISTED below are chairmen and secretaries of all ASTM technical committees. These are published in advance of the 1953 ASTM Year Book which is scheduled to appear shortly, and will contain complete lists of officers and personnel of the various committees. The asterisk indicates new officers.

Committee	Chairman	Secretary
A-1 on Steel	H. B. Oatley, Great Neck, L. I., N. Y.	J. S. Worth, Bethlehem Steel Co., Bethlehem, Pa.
A-2 on Wrought Iron	A. D. Morris, Bayonne Bolt Corp., New York, N. Y.	L. S. Crane, Southern Railway System, Alexandria, Va.
A-3 on Cast Iron	J. S. Vanick, International Nickel Co., Inc., New York, N. Y.	D. E. Krause, Gray Iron Research Inst., Inc., Columbus, Ohio
A-5 on Corrosion of Iron and Steel	A. P. Jahn, Bell Telephone Laboratories, Inc., Murray Hill, N. J.	C. P. Larrabee, United States Steel Co., Vandergrift, Pa.
A-6 on Magnetic Properties	R. L. Sanford, National Bureau of Standards, Washington, D. C.	*M. Getting, Jr., Allis-Chalmers Mfg. Co., Pittsburgh, Pa.
A-7 on Malleable Iron Castings	W. A. Kennedy, Grinnell Co. Inc., Providence, R. I.	J. H. Lansing, Malleable Founders Soc., Cleveland, Ohio
A-9 on Ferro Alloys	W. C. Bowden, Jr., Ledoux & Co., Inc., New York, N. Y.	G. F. Comstock, The Titanium Alloy Manufacturing Co., Niagara Falls, N. Y.
A-10 on Iron-Chromium, Iron - Chromium - Nickel and Related Alloys	Jerome Strauss, Vanadium Corp. of America, New York, N. Y.	M. A. Cordovi, The Babcock Wilcox Co., New York, N. Y.
B-1 on Wires for Electrical Conductors	D. Halloran, Consolidated Edison Co. of New York, Inc., New York, N. Y.	A. A. Jones, Anaconda Wire and Cable Co., Hastings-on-Hudson, N. Y.
B-2 on Non-Ferrous Metals and Alloys	B. W. Gonser, Battelle Memorial Inst., Columbus, Ohio	G. H. LeFevre, U. S. Smelting, Refining & Mining Co., New York, N. Y.
B-3 on Corrosion of Non-Ferrous Metals and Alloys	K. G. Compton, Bell Telephone Laboratories, Inc., Murray Hill, N. J.	A. W. Tracy, The American Brass Co., Waterbury, Conn.
B-4 on Electrical Heating, Resistance, and Related Alloys	S. A. Standing, Tung-Sol Lamp Works, Inc., Bloomfield, N. J.	Stanton Umbreit, Radio Corp. of America, Harrison, N. J.
B-5 on Copper and Copper Alloys, Cast and Wrought	G. H. Harnden, General Electric Co., Schenectady, N. Y.	V. P. Weaver, The American Brass Co., Waterbury, Conn.
B-6 on Die-Cast Metals and Alloys	W. Babington, Bell Telephone Laboratories, Inc., Murray Hill, N. J.	G. L. Werley, The New Jersey Zinc Co., Palmerton, Pa.
B-7 on Light Metals and Alloys, Cast and Wrought	I. V. Williams, Bell Telephone Laboratories, Inc., Murray Hill, N. J.	R. B. Smith, Reynolds Metals Co., Louisville, Ky.
B-8 on Electrodeposited Metallic Coatings	C. H. Sample, The International Nickel Co., New York, N. Y.	R. B. Saltonstall, The Udylite Corp., Detroit, Mich.
B-9 on Metal Powders and Metal Powder Products	*F. V. Lenel, Rensselaer Polytechnic Inst., Troy, N. Y.	*C. G. Johnson, Presmet Corp., Worcester, Mass.
C-1 on Cement	R. R. Litehiser, Ohio State Highway and Research Laboratory, Columbus, Ohio	W. S. Weaver, Canada Cement Co., Ltd., Montreal, Canada
C-2 on Magnesium Oxychloride and Oxysulfate Cements	.....	J. B. James, Oxychloride Cement Assn., Washington, D. C.
C-3 on Chemical Resistant Mortars	Beaumont Thomas, Stebbins Engineering and Manufacturing Co., Watertown, N. Y.	J. R. Allen, E. I. du Pont de Nemours and Co., Wilmington, Del.
C-4 on Clay Pipe	J. C. Riedel, Board of Estimate, City of New York, N. Y.	R. G. Scott, Clay Products Assn., Chicago, Ill.
C-7 on Lime	J. A. Murray, Massachusetts Institute of Technology, Cambridge, Mass.	R. S. Boynton, National Lime Assn., Washington, D. C.
C-8 on Refractories	R. B. Sosman, Rutgers University, New Brunswick, N. J.	W. R. Kerr, Armstrong Cork Co., Beaver Falls, Pa.
C-9 on Concrete and Concrete Aggregates	L. W. Teller, U. S. Bureau of Public Roads, Washington, D. C.	Bryant Mather, Waterways Experiment Station, Jackson, Miss.

Committee	Chairman	Secretary
C-11 on Gypsum	.....	L. H. Yeager, Gypsum Assn., Chicago, Ill.
C-12 on Mortars for Unit Masonry	J. M. Hardesty, Bell Telephone Laboratories Inc., Murray Hill, N. J.	J. A. Murray, Massachusetts Institute of Technology, Cambridge, Mass.
C-13 on Concrete Pipe	R. R. Litehiser, Ohio State Highway and Research Laboratory, Columbus, Ohio	H. F. Peckworth, American Concrete Pipe Assn., Chicago, Ill.
C-14 on Glass and Glass Products	L. G. Ghering, Preston Laboratories, Butler, Pa.	F. V. Tooley, University of Illinois, Urbana, Ill.
C-15 on Manufactured Masonry Units	J. W. Whittemore, Virginia Polytechnic Inst., Blacksburg, Va.	M. H. Allen, Structural Clay Products Inst., Washington, D. C.
C-16 on Thermal Insulating Materials	E. R. Queer, The Pennsylvania State College, State College, Pa.	*W. L. Gantz, American Viscose Corp., Philadelphia, Pa.
C-17 on Asbestos-Cement Products	H. R. Snoke, National Bureau of Standards, Washington, D. C.	C. C. Kelsey, Asbestos Cement Products Assn., New York, N. Y.
C-18 on Natural Building Stones	L. W. Currier, U. S. Geological Survey, Washington, D. C.	F. S. Eaton, Research and Design Inst., New Haven, Conn.
C-19 on Structural Sandwich Constructions	E. W. Kuenzi, U. S. Forest Products Laboratory, Madison, Wis.	*W. L. Emerson, Goodyear Tire and Rubber Co., Akron, Ohio
C-20 on Acoustical Materials	H. A. Leedy, Armour Research Foundation, Chicago, Ill.	H. J. Sabine, The Celotex Corp., Chicago, Ill.
C-21 on Ceramic Whiteware	C. G. Harman, Battelle Memorial Inst., Columbus, Ohio	R. F. Geller, National Bureau of Standards, Washington, D. C.
C-22 on Porcelain Enamel	W. N. Harrison, National Bureau of Standards, Washington, D. C.	G. H. Spencer-Strong, Pemco Corp., Baltimore, Md.
D-1 on Paint, Varnish, Lacquer and Related Products	W. T. Pearce, Bala-Cynwyd, Pa.	W. A. Gloger, National Lead Co., Brooklyn, N. Y.
D-2 on Petroleum Products and Lubricants	O. L. Maag, Timken Roller Bearing Co., Canton, Ohio	W. T. Gunn, American Petroleum Inst., New York, N. Y.
D-3 on Gaseous Fuels	A. W. Gauger, The Pennsylvania State College, State College, Pa.	K. R. Knapp, American Gas Assn., Cleveland, Ohio
D-4 on Road and Paving Materials	C. A. Carpenter, Bureau of Public Roads, Washington, D. C.	B. A. Anderton, The Barrett Div., Allied Chemical and Dye Corp., Edgewater, N. J.
D-5 on Coal and Coke	W. W. Anderson, Commercial Testing and Engineering Co., Chicago, Ill.	O. P. Brysch, Institute of Gas Technology, Chicago, Ill.
D-6 on Paper and Paper Products	W. R. Willets, Titanium Pigment Corp., New York, N. Y.	R. H. Carter, General Electric Co., Schenectady, N. Y.
D-7 on Wood	L. J. Markwardt, U. S. Forest Products Laboratory, Madison, Wis.	L. W. Smith, U. S. Forest Service, Washington, D. C.
D-8 on Bituminous Waterproofing and Roofing Materials	H. R. Snoke, National Bureau of Standards, Washington, D. C.	G. W. Robbins, The Texas Co., New York, N. Y.
D-9 on Electrical Insulating Materials	A. H. Scott, National Bureau of Standards, Washington, D. C.	B. E. Ely, E. I. du Pont de Nemours and Co., Wilmington, Del.
D-10 on Shipping Containers	*G. E. Falkenau, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.	*R. F. Uncles, American Cyanamid Co., New York, N. Y.
D-11 on Rubber and Rubber-Like Materials	Simon Collier, Johns-Manville Corp., New York, N. Y.	A. W. Carpenter, The B. F. Goodrich Co., Akron, Ohio
D-12 on Soaps and Other Detergents	J. C. Harris, Monsanto Chemical Co., Dayton, Ohio	H. R. Suter, Wyandotte Chemicals Corp., Wyandotte, Mich.
D-13 on Textile Materials	W. D. Appel, National Bureau of Standards, Washington, D. C.	W. H. Whitcomb, Cranston, R. I.
D-14 on Adhesives	Gerald Reinsmith, Office, Chief of Ordnance, ORDTB, Washington, D. C.	L. M. Perry, Nashua Corp., Nashua, N. H.
D-15 on Engine Antifreezes	H. R. Wolf, General Motors Corp., Detroit, Mich.	C. F. Graham, Wyandotte Chemicals Corp., Wyandotte, Mich.
D-16 on Industrial Aromatic Hydrocarbons	D. F. Gould, The Borden Co., Philadelphia, Pa.	F. J. Powell, The Barrett Div. Allied Chemical and Dye Corp., Philadelphia, Pa.
D-17 on Naval Stores	V. E. Grotlisch, Production and Marketing Administration, Dept. of Agriculture, Washington, D. C.	W. A. Kirklin, Hercules Powder Co., Wilmington, Del.
D-18 on Soils for Engineering Purposes	E. J. Kilcawley, Rensselaer Polytechnic Inst., Troy, N. Y.	W. G. Holtz, Bureau of Reclamation, Denver, Colo.

New American Standard for Small, Solid Rivets

REPRESENTING a consolidation of two former standards, B 18a and B 18g (tinners', coopers', and belt rivets) the new American Standard for Small Solid Rivets (ASA B 18.1—1953) covers standard types of small solid rivets designated as flat head, countersunk head, button head, pan head, truss head, tanners', coopers', and belt rivets. The standard developed one set of dimensional tolerances for all the types, but made no changes in basic dimensions.

The new American Standard is published by The American Society of Mechanical Engineers, 29 W. 39th St., New York 18, N. Y. Individual copies are available at $1 each.

NBS Vibration Generator for Electron Tubes

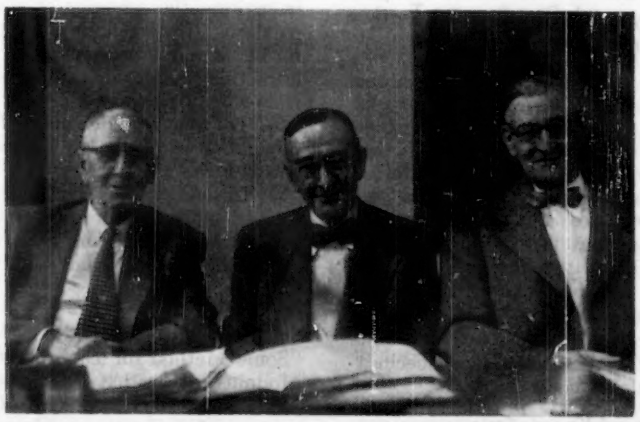
ELECTRONIC equipment is being called upon increasingly for applications where it is subjected to severe vibration which requires development of components rugged enough to withstand strenuous service. Electron tubes present a special problem with respect to severe vibration. In addition to being strong enough not to fail mechanically, they must be low in microphonics—particularly difficult in miniaturized equipment.

An improved wide-range vibration generator developed at the National Bureau of Standards for study of low microphonic tubes produces accelerations up to 20 times that of gravity and is flat within 20 per cent over the unusually wide range of 100 to 10,000 cps. The tube under study is fitted into a hole in the vibrator's moving element, or armature, which is a cylindrical block of nonmagnetic material with a "voice coil"—for audio-frequency driving voltage—at its lower end. Two flexible metal strips hold the armature centered in an electromagnetic field structure powered by 40 w of 120-v current.

In the NBS vibrator the upper frequency limit is raised by making the armature simple and rugged, constructing it of linen bakelite which has a moderately high ratio of rigidity to weight.

Development of this vibrator was dependent upon the previous development of a small barium titanate accelerometer capable of measuring vibration frequencies to 20 kilocycles at acceleration levels of 0.2 to 10,000 g. One of these accelerometers is mounted on the armature of the vibrator to sense the vibration amplitude.

Committee	Chairman	Secretary
D-19 on Industrial Water	Max Hecht, 25 Valley Rd., Drexelbrook, Drexel Hill, Pa.	*B. W. Dickerson, Hercules Experiment Station, Wilmington, Del.
D-20 on Plastics	R. K. Witt, Johns Hopkins Univ., Baltimore, Md.	G. M. Armstrong, Tennessee Eastman Div., Eastman Kodak Co., Kingsport, Tenn.
D-21 on Wax Polishes and Related Material	W. W. Walton, National Bureau of Standards, Washington, D. C.	B. S. Johnson, Franklin Research Co., Philadelphia, Pa.
D-22 on Methods of Atmospheric Sampling and Analysis	L. C. McCabe, Bureau of Mines, Dept. of Interior, Washington, D. C.	H. H. Schrenk, Industrial Hygiene Foundation, Pittsburgh, Pa.
D-23 on Cellulose and Cellulose Derivatives	F. A. Simmonds, U. S. Forest Products Laboratory, Madison, Wis.	W. W. Becker, Hercules Powder Co., Wilmington, Del.
E-1 on Methods of Testing	J. R. Townsend, Bell Telephone Laboratories, Murray Hill, N. J.	P. J. Smith, American Society for Testing Materials, Philadelphia, Pa.
E-2 on Emission Spectroscopy	B. F. Scribner, National Bureau of Standards, Washington, D. C.	J. H. Coulliette, University of Chattanooga, Chattanooga, Tenn.
E-3 on Chemical Analysis of Metals	J. W. Stillman, E. I. du Pont de Nemours and Co., Wilmington, Del.	H. Kirtchik, General Electric Co., Lynn, Mass.
E-4 on Metallography	L. L. Wyman, General Electric Co., Schenectady, N. Y.	Mary Norton, Watertown Arsenal, Watertown, Mass.
E-5 on Fire Tests of Material and Constructions	A. L. Brown, Associated Factory Mutual Fire Insurance Cos., Boston, Mass.	R. C. Corson, Associated Factory Mutual Fire Insurance Cos., Boston, Mass.
E-6 on Methods of Testing Building Constructions	J. A. Liska, U. S. Forest Products Laboratory, Madison, Wis.	R. A. Biggs, Franki Foundation Co., New York, N. Y.
E-7 on Non-Destructive Testing	J. H. Bly, Pratt & Whitney Aircraft, East Hartford, Conn.	D. T. O'Connor, Naval Ordnance Laboratory, Silver Spring, Md.
E-8 on Nomenclature and Definitions	P. V. Faragher, Aluminum Company of America, Pittsburgh, Pa.	P. J. Smith, American Society for Testing Materials, Philadelphia, Pa.
E-9 on Fatigue	R. E. Peterson, Westinghouse Electric Corp., East Pittsburgh, Pa.	O. J. Horger, The Timken Roller Bearing Co., Canton, Ohio
E-10 on Radioactive Isotopes	D. M. McCutcheon, Ford Motor Co., Dearborn, Mich.	C. E. Weber, General Electric Co., Schenectady, N. Y.
E-11 on Quality-Control of Materials	H. F. Dodge, Bell Telephone Laboratories, New York, N. Y.	O. P. Beckwith, Alexander Inc., Yonkers, N. Y.
E-12 on Appearance	M. R. Paul, Eagle-Picher Sales Co., Washington, D. C.	Daniel Smith, Interchemical Corp., New York, N. Y.
E-13 on Absorption Spectroscopy	E. J. Rosenbaum, Sun Oil Co., Norwood, Pa.	W. S. Young, Atlantic Refining Co., Philadelphia, Pa.
E-14 on Mass Spectrometry	W. S. Young, Atlantic Refining Co., Philadelphia, Pa.	J. G. Hutton, General Electric Co., Schenectady, N. Y.



Eighty-nine years of productive ASTM membership are represented in this picture of Dalton G. Miller, former Materials Engineer, Bureau of Public Roads; Earl F. Kelley, Chief, Physical Research Branch, Bureau of Public Roads; and William J. Schlick, Research Professor, Engineering Experiment Station, Iowa State College. These men were photographed at the Spring meeting of the Drain Tile subcommittee (of which Mr. Miller is chairman) of ASTM Committee C-15 on Manufactured Masonry Units.

Calendar of Other Societies' Events

"Long" and "short" calendars will appear in alternate BULLETINS. The "short" calendar notes meetings in the few immediate weeks ahead—The "long" calendar for months ahead.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Sept. 28–30, Petroleum Mechanical Engineering Conference, Rice Hotel, Houston Tex.

ASSOCIATION OF IRON AND STEEL ENGINEERS—Sept. 28–Oct. 1, Annual Convention, William Penn Hotel, Pittsburgh, Pa.

SOCIETY OF AUTOMOTIVE ENGINEERS—Sept. 29–Oct. 3, National Aero. Meeting, Aircraft Engineering Display, and Aircraft Production Forum, Statler Hotel, Los Angeles, Calif.

TEXTILE CHEM. MANUFACTURERS ASSN.—Oct. 1–2, Annual Meeting, Claridge Hotel, Atlantic City, N. J.

AMERICAN CERAMIC SOCIETY—Oct. 2–3, Materials and Equipment, White Wares, Bedford Springs Hotel, Bedford, Pa.

AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Oct. 5–7, Fall Meeting, Hotel Sheraton, Rochester, N. Y.

PACIFIC COAST BUILDING OFFICIALS CONFERENCE—Oct. 5–9, 31st Annual Business Meeting, Hotel Huntington, Pasadena, Calif.

NATIONAL ASSOCIATION OF CORROSION ENGINEERS—Oct. 7–9, Mayo Hotel, Tulsa, Okla.

ILLINOIS INSTITUTE OF TECHNOLOGY—Oct. 8–9, 9th National Conference on Industrial Hydraulics, Hotel Sheraton, Chicago, Ill.

GRAY IRON FOUNDERS' SOCIETY—Oct. 8–9, Annual Meeting, New Hotel Jefferson, St. Louis, Mo.

FEDERATION OF SEWAGE AND INDUSTRIAL WASTES ASSOCIATIONS—Oct. 13–16, Annual Convention, Municipal (Bayfront Park) Auditorium, Miami, Fla.

AMERICAN SOCIETY FOR ENGINEERING EDUCATION AND THE EDUCATIONAL COUNCIL FOR PROFESSIONAL DEVELOPMENT—Oct. 14–17, Joint Meeting, Hotel Statler, New York, N. Y.

AMERICAN STANDARDS ASSOCIATION—Oct. 19–21, 4th National Standardization Conference, The Waldorf-Astoria, New York, N. Y.

CONFERENCE ON ELECTRICAL INSULATION—Oct. 19–21, Annual Meeting, Pocono Manor Inn, Pocono Manor, Pa.

AMERICAN SOCIETY OF CIVIL ENGINEERS—Oct. 19–23, Annual Convention, Hotel Statler, New York City, N. Y.

AMERICAN SOCIETY FOR METALS—Oct. 19–23, National Metal Congress & Exposition, Hotel Statler, Cleveland, Ohio.

AMERICAN WELDING SOCIETY—Oct. 19–23, 33rd Annual Meeting, Hotel Cleveland, Cleveland, Ohio.

AMERICAN GAS ASSOCIATION—Oct. 26–29, Annual Conference, Kiel Auditorium, St. Louis, Mo.

ASSOCIATION OF CONSULTING CHEMISTS AND CHEMICAL ENGINEERS—Oct. 27, Annual Meeting, Hotel Belmont Plaza, New York, N. Y.

THE AMERICAN SOCIETY OF MECHANICAL ENGINEERS—Oct. 29–30, Fuels-AIME Coal Conference, Conrad Hilton Hotel, Chicago, Ill.

SOCIETY OF AUTOMOTIVE ENGINEERS—Oct. 29–30, International Production Meeting, Royal York Hotel, Toronto, Ont., Canada.

SOCIETY OF RHEOLOGY—Oct. 29–30, Annual Meeting, Hotel New Yorker, New York, N. Y.

AMERICAN CONCRETE INSTITUTE—Oct. 29–30, Southwest Regional Meeting, Rice Hotel, Houston, Tex.

Some Unsolved Problems

Committees Submit Intriguing Questions: What We Know and What We Would Like to Know

About three years ago the ASTM Administrative Committee on Research requested the various technical committees to submit their current research problems. These statements were reviewed by the ACR and the decision taken that such problems be published serially in the ASTM Bulletin and reprinted for distribution to various engineering and scientific schools and to research institutions and testing laboratories as a suggested basis for possible research work.

This reprint pamphlet has been revised and expanded to include additional problems which are also being printed in the present series of Bulletins.

The revised pamphlet can be obtained from ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

Appearing in this issue are:

Appearance of Paper
Practical Role of the Sonic Moduli of Elasticity and Rigidity in Testing Heavy Refractories
Reason for Improved Load Test Behavior of Fireclay Refractories Resulting from Hard Firing
Tension Testing of Paper
Surface Breakdown of Solid Electrical Insulating Materials under the Influence of Electric Fields

Appearance of Paper

Statement of Unsolved Problems Contributed by Committee D-6 on Paper and Paper Products

Problem:

The appearance of paper may generally be considered as one of its most important characteristics. The over-all appearance is a combination of many complex factors, psychological as well as physical. Some of these such as brightness, color, gloss, and opacity can be measured and approximately described by physical and optical methods. Others are much more elusive, for example "texture" means many things to different people although in the paper industry it may be considered as closely analogous to "finish." The problem of appearance can only be stated in the broadest terms since a complete and detailed discussion would require volumes.

Present State of Knowledge:

The literature dealing with the many phases having to do with the appearance of paper is voluminous. Methods for reflectance, color, opacity and gloss are in common use, but the interpretation of the results obtained especially when considered in their relationship to over-all appearance is difficult, probably because of the complications introduced by the psychological factors involved, as it applies to all materials. The problem of appearance is receiving the closest attention of ASTM Committee E-12 on Appearance.

Questions That Need to Be Answered:

1. Such terms as "gloss," "sheen," and "glare" should be defined in terms of actual instrument readings taking into consideration the incident angle and color of illuminant, as well as the color of the sample under consideration.
2. The "brightness" of paper should be defined in terms of instrument readings taking into consideration the color of the illuminant, and the "gloss" and the color of the sample.
3. The "texture" and "finish" of paper should be defined in terms of measurable properties as noted above.
4. The "appearance" of paper should be described in such terms as to correlate with the "appearance" of other materials and surfaces such as plastics and textiles.

Introductory References:

(1) "Paper and Paperboard: Characteristics, Nomenclature and Significance of Tests," Am. Soc. Testing Mats., Oct., 1951, especially Parts I, III, and IV, pp. 61, 74, 84, and 90. (Issued as separate publication, *STP No. 60-A.*)

Additional information may be obtained from W. R. Willets, Chairman of Committee D-6, Titanium Pigment Corp., 99 Hudson St., New York 13, N. Y.

Practical Rôle of the Sonic Moduli of Elasticity and Rigidity in Testing Heavy Refractories

Statement of Unsolved Problem Contributed by Committee C-8 on Refractories

Problem:

The determination of sonic moduli of elasticity and rigidity represents a convenient, economical non-destructive test which perhaps may be used in place of or in combination with existing destructive mechanical test procedures. The eventual aim would be to establish a standard procedure and work out values and limits which might be used in design, specifications, and quality control.

Present State of Knowledge:

Rather limited work has been published on the sonic modulus of elasticity and practically none at all on the sonic modulus of rigidity of heavy refractories. Baab and Kraner (1) have published results to indicate that sonic modulus of elasticity is more sensitive to variations in firing treatment than porosity and specific gravity and, of course, does not destroy the sample like modulus of rupture. They suggest the use of this property as a control test during manufacture and as a consumer's specification check.

The test procedure has been rather extensively reported in connection with concrete testing and has been studied in detail from a theoretical standpoint. ASTM Method C 215 (2) issued as tentative in 1947 and revised in 1951, represents a delineation of present knowledge on the subject prepared under the jurisdiction of Committee C-9 on Concrete and Concrete Aggregates.

Work at the University of Illinois on heavy refractories has been in progress since 1948 under the supervision of a member of Subcommittee II on Research of Committee C-8 on Refractories.

Questions That Need to Be Answered:

1. What is the general magnitude of values of sonic moduli of elasticity and rigidity which can be expected in various classes of heavy refractories?
2. How do these moduli reflect variations in firing treatment and can any correlation with such properties as modulus of rupture, crushing strength, porosity, specific gravity, etc., be expected?
3. Do these moduli reflect defects or inhomogeneities which may exist within the refractory shape? How will residual strain due to inhomogeneities affect values of the moduli?
4. To what precision must frequency of vibration, weight, and dimensions be measured to produce a value significantly free of experimental error?
5. A value for Poisson's ratio is assumed in making the modulus of elasticity calculation. Does lack of data on this value for heavy refractories influence results and is modulus of rigidity more satisfactory from this viewpoint?
6. To what extent can such values of moduli be useful in design, control, and specification?
7. Is sonic testing of this type at elevated temperature of any value?
8. Does sonic testing have any rôle in predicting spalling behavior?

Selected References:

(1) K. A. Baab and H. M. Kraner, "Sonic Method for Determining Young's Modulus of Elasticity," *Journal*, Am. Ceramic Soc., Vol. 31, pp. 318–320 (1948).

(2) ASTM Tentative Method of Test for Fundamental Transverse Frequency of Concrete Specimens for Calculating Young's Modulus of Elasticity (C 215). 1952 Book of ASTM Standards, Part 3, p. 1072.

(3) Gerald Pickett, "Equations for Computing Elastic Constants from Flexural and Torsional Resonant Frequencies of Vibration of Prisms and Cylinders," *Proceedings*, Am. Soc. Testing Mats., Vol. 45, pp. 846–865 (1945). (Also *Bulletin No. 7* of Portland Cement Association Research Laboratories, Chicago, Ill.)

Additional information may be obtained from R. E. Birch, Chairman of Subcommittee II on Research of Committee C-8, Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh 22, Pa.

Reason for Improved Load Test Behavior of Fireclay Refractories Resulting from Hard Firing

Statement of Unsolved Problem Contributed by Committee C-8 on Refractories

Problem:

Firing fireclay refractories to higher temperatures decreases their subsidence under load at high temperature as in ASTM Standard Method of Testing Refractory Brick Under Load at High Temperatures (C 16)(1).

Present State of Knowledge:

The standard load test requires holding at the maximum temperature for only 1.5 hr. Nevertheless, Crookston and Torgeson (2) have shown that the advantage of harder firing for a super-duty fireclay brick was still retained after 100 hr. Not only did lighter-burned brick subside more than harder-burned brick of essentially the same composition in the early hours of the test but their hourly subsidence rate was greater also in the last 10 to 15 hr of special 100-hr tests at 2400 and 2600 F.

Subsidence is due to the liquid phase becoming actively fluid within the refractory during the load test as a result of partial melting. For a given fireclay refractory, the amount and composition of the liquid *under equilibrium conditions* will be the same regardless of prior heat treatment. The solution of this problem may not lie in questioning the degree of approach to equilibrium, so much as in studying the character of the crystalline structure. The principal minerals present are mullite and presumably cristobalite. Much interest attaches to the degree of mullitization. It is not likely that the percentage of mullite varies appreciably for fireclay brick of a given composition subjected only to normal differences in burning treatment, but the character of the mullite structure (crystal size, placement, interlocking, etc.) may show real differences.

It has been suggested that the harder burn may alter the composition by causing the least refractory constituents to volatilize. This has not been supported by such data as are available, but should not be ruled out.

Bleininger and Brown (5) noted that well-burned brick stood up better under load than lighter-burned products, and concluded that this was due "not only to the greater compactness of the body (which does not always develop in harder burning), but also to the change in the composition of the bonding material where such is used. In other words, hard burning will cause the plastic clay, usually decidedly less refractory than the flint, to dissolve some of the fine part of the better material, thus increasing its own refractoriness and hence its resistance to load conditions." This viewpoint, which assumes the absence of equilibrium conditions, can hardly be applied with force to the current problem in so far as it involves super-duty fireclay brick; in this class of refractories there is little, if any, difference in the refractoriness of bond clay and other constituents.

Questions That Need to Be Answered:

What mineralogic, chemical, or physical changes may explain this improvement?

Introductory References:

(1) 1952 Book of ASTM Standards, Part 3, p. 623.

(2) J. A. Crookston and D. R. Torgeson, "Long-Time Load Tests on Commercial Classes of Fireclay Brick," *Journal*, Am. Ceramic Soc., Vol. 35, p. 265 (1952).

(3) F. H. Norton, "Refractories," Third Edition, Chapter 14, "Load-Bearing Capacity of Refractories," p. 401, McGraw-Hill Book Company, Inc., New York (1949).

(4) F. H. Clews, H. M. Richardson, and A. T. Green, "The Behavior of Refractory Materials Under Stress at High Temperatures," Parts I and II, *Transactions*, British Ceramic Soc., Vol. 43, p. 223 (1944).

(5) A. V. Bleininger and G. H. Brown, "The Behavior of Fire Brick Under Load Conditions at a Temperature of 1300 C," *Transactions*, Am. Ceramic Soc., Vol. 12, pp. 337–347 (1910).

Additional information may be obtained from R. E. Birch, Chairman of Subcommittee II on Research of Committee C-9, Harbison-Walker Refractories Co., Farmers Bank Bldg., Pittsburgh 22, Pa.

Tension Testing of Paper

Statement of Unsolved Problem Contributed by Committee D-6 on Paper and Paper Products

Problem:

The tensile strength of paper, both wet and dry, is an important property in many end uses, either considered alone or in conjunction with other properties such as stretch and elasticity which may be related. While present methods are probably satisfactory as far as they go, they do not take into account newer types of instruments which make use of strain gauges and other devices.

Present State of Knowledge:

Tension testing was probably one of the first methods to be developed and the literature on it is copious. However, the relationship between tensile strength and stretch, elasticity, and other properties which are probably related has never been thoroughly investigated. Neither has the effect of repeated applying and releasing strain on a paper web on the ultimate tensile strength been determined. Correlations between tensile strength methods and results for paper and other thin sheet materials such as felts, flocs, films, rubbers, laminants, and textiles together with practical applications to end use where one might be substituted for another have not been developed. For this reason ASTM Committee E-1 on Methods of Testing has been requested to sponsor a symposium on the tension testing of thin sheet materials in 1954.

Questions That Need to Be Answered:

1. Investigate all types of tension testers, old and new, to determine their adaptability to paper and correlate results obtained.
2. Investigate relationship between tensile strength and other properties such as stretch and elasticity.
3. Determine the relationship between tests on paper and on other materials as they affect end use.
4. Determine the effect of repeated applying and releasing strains on paper on the ultimate tensile strength in conjunction with other properties.

Introductory References:

(1) "Paper and Paperboard: Characteristics, Nomenclature and Significance of Tests," Am. Soc. Testing Mats., Oct., 1951, p. 98; 106. (Issued as separate publication, *STP No. 60-A*.)

Additional information may be obtained from W. R. Willets, Chairman of Committee D-6, Titanium Pigment Corp., 99 Hudson St., New York 13, N. Y.

Surface Breakdown of Solid Electrical Insulating Materials under the Influence of Electric Fields

Statement of Unsolved Problem Contributed by Committee D-9 on Electrical Insulating Materials

Problem:

The problems relating to the testing of solid electrical insulating materials for resistance to surface breakdown under the influence of essentially tangential electric fields may be divided into two main categories, as follows:

1. Those relating specifically to ASTM Tentative Method of Test for High-Voltage, Low-Current Arc Resistance of Solid Electrical Insulating Materials (D 495)(1).
2. Those pertaining to tests under conditions other than those in which a specified high-voltage, low-current arc between prescribed electrodes in contact with the surface of the dielectric may be involved.

It seems safe to say that Method D 495, a revised and refined form of the test originally described by Race and Warner (2) in 1935 and later made ASTM Standard Method of Test for Arc-Resistance of Solid Electrical Insulating Materials under designation D 495 – 42, is probably among the best test methods in existence from the standpoints of the precise definition of

scope, exact description of apparatus, procedure, etc. Nevertheless, there are some unsolved problems that have not been satisfactorily resolved to date but which conceivably might yield to a systematic study. One of these is a less than satisfactory agreement among laboratories in round-robin tests on certain plastic samples, particularly those of the melamine type. Another has to do with the question of cleaning electrodes, which has resulted in something of a controversy. An apparently minor circuit detail resulting in a "back-feed" condition when switch *S*1/8 is closed and *C*1/8 is open (Fig. 1 of D 495) has been cited and requires investigation as to its significance in affecting test results. Some considerably more abstruse and possibly less readily answered questions have been brought up concerning the point in time on the voltage wave of the making and breaking of the primary circuit during the first, that is, the 1/8–10, step in the test. Still other questions have come up regarding the applicability of D 495 – 48 T to the testing of thin films of adhesives, varnished cambric, and the like. Of a more fundamental character is the problem of devising means of changing or supplementing the present stepwise procedure to provide for a continuous increase in arc severity during the course of a test. To date the only serious attempt to accomplish this is represented by the special timing device developed by R. E. Wolf of Spaulding Fibre Co. This timing device is now undergoing investigation in a special round-robin among nine different laboratories. This fact, however, should not preclude consideration of other possible means of accomplishing the desired aim of eliminating or reducing the tendency of arc resistance data to "bunch" at or just above multiples of 60 sec. Finally, under problems relating specifically to D 495, it has for some time been rather puzzling that reports should come in to the effect that ignition equipment manufacturers do not find the present ASTM method adequate for their purposes.

Problems in the second category obviously cover a much wider range and variety of tests. Race and Warner (2) in 1935 briefly reviewed about ten different types of test for arc-resistance, tracking, creepage-path resistance, etc. Yarsley and Grant (3), in their excellent survey in the form of an E.R.A. Report issued in 1948, have described the numerous tests for estimating the susceptibility of insulating materials to tracking, classifying them into those in which an arc or spark discharge between electrodes is caused to play on the surface, and those in which a current is passed through a layer of conducting material (such as a salt-water solution) on the surface. Yarsley and Grant's paper reviews several methods in both of these categories and gives a very valuable list of 105 references. In a later E.R.A. Report edited by Yarsley (4) a description of an improved version of the Detroit Edison salt-water dropping test is given. Yarsley and Owen (5) have also published a paper dealing with recent work on tracking in solid insulating materials, citing nine references to literature. In this country, Olyphant (6,7) at Princeton has contributed informatively to the general problem of evaluating arc resistance and has also published preliminary results of radio frequency arc and corona tests. Knappe (8) has reviewed work done in Germany since 1940 on leakage current and tracking on insulating surfaces, citing 28 references. Wandeberg (9) has critically discussed and compared various common test methods for evaluating the resistance of electrical insulating materials to tracking, and has recommended the Micafil steam test (MICAFIL A.-G., Switzerland), which has also been mentioned by Yarsley and Grant (3). The problem as far as ASTM is concerned appears to be one of deciding whether consideration should be given to extending coverage of tests for surface breakdown of insulation beyond that now given in D 495. Perhaps a new test method or methods incorporating the more desirable features of many of those referred to above might be a valuable and useful addition to supplement the somewhat limited and specialized test conditions of D 495.

Present State of Knowledge:

The present state of knowledge concerning the problems presented above is reasonably clear from the preceding section and nothing would appear to be gained by further statements here.

Questions That Need to Be Answered:

1. What are the reasons for the rather poor agreement among laboratories using the present ASTM Method D 495 arc-resistance apparatus in testing certain plastics, particularly those of the melamine type?

2. Is it really necessary that a specific model of high-voltage transformer be recommended as is done in D 495, or might it not be possible to permit the use of a transformer of any convenient rating equal to or greater than 12 kv and 1 kva, as was suggested by Race and Warner (2) in their original paper describing the test procedure on which the present ASTM method is based?

3. Will separation of the return lead connection of the indicating lamp *L* in Fig. 1, D 495 from the return leads of the timer *T* and motor *M* and connecting it to the slider of autotransformer *Ta* to eliminate a "back-feed" when *S*1/8 is closed and *C*1/8 is open have any effect on the operation of the circuit in running a test, or may this "back-feed" condition be ignored as insignificant?

4. What features of D 495 are responsible for its reported failure to meet the requirements of ignition equipment manufacturers, when the nature of the test itself would seem to be such as to simulate the conditions that exist in the operation of such equipment?

5. How may the ASTM D 495 Method be modified to provide for a continuously increasing arc severity instead of the present abrupt increases at 1-min time intervals?

6. Which of the numerous types of arc-resistance, tracking-resistance, creep-path resistance, and similar tests described in the literature need to be investigated as the basis for possible future ASTM test methods?

Introductory References:

(1) 1952 Book of ASTM Standards, Part 16, p. 1136.

(2) H. H. Race and F. W. Warner, *General Electric Review*, Vol. 38, pp. 97–102, February, 1935.

(3) V. E. Yarsley and W. J. Grant, The British Electrical and Allied Industries Research Association Technical Report Reference L/T177 (1948).

(4) V. E. Yarsley (Ed.), The British Electrical and Allied Industries Research Association Technical Report Reference L/T237 (1950).

(5) V. E. Yarsley and W. D. Owen, *British Plastics*, Vol. 24, pp. 122–127, April, 1951.

(6) M. Olyphant, Jr., Princeton University Plastics Lab. Technical Report 18G, July 14, 1950; Department of the Army Project 3-99-15-022; Signal Corps Project 152-B.

(7) M. Olyphant, Jr., ASTM Bulletin No. 181, pp. 60–67, April, 1952.

(8) W. Knappe, Elektrotechnische Zeitschrift (ETZ), Vol. 72, pp. 224–228, April 15, 1951.

(9) E. Wandeberg, *Kunststoffe*, Vol. 41, pp. 374–376, November, 1951.

Additional information may be obtained from Thomas Hazen, Chairman, Section G, Subcommittee XII, ASTM Committee D-9, Bakelite Company, Bloomfield, N. J.

Philips to Hold Diffraction School in October

The Fall session of the semiannual X-Ray Diffraction School will be held at the plant of North American Philips Co., Inc., 750 S. Fulton Ave., Mount Vernon, N. Y., during the week of October 5 to 9.

Monday through Thursday, the sessions involve extensive classroom and laboratory work wherein opportunity is provided for participants to discuss their own problems and to become familiar with actual use of all types of equipment.

Basic subjects to be covered by prominent educators and scientists will include X-ray diffraction, new high- and low-temperature camera techniques, fluorescence analysis, Geiger-counter X-ray spectrometer, and electron microscopy and electron diffraction.

Reservations should be made at the earliest possible date. There is no registration fee.

An Analytical Study of the Die-Casting Process*

By Bruno Sachs[1]

The Problem and Need for the Study

During the past 30 years, the field of application of die castings has grown widely and the process of die casting is, by now, an important industrial factor in the economical mass production of non-ferrous metal parts. Progress in the method of production of die castings has followed empirical lines. Die casting is still considered an art, and experience is most essential for its successful execution.

In February, 1947, ASTM Committee B-6 on Die-Cast Metals and Alloys, recognizing that a scientific approach toward a better understanding and control of the variables in the process would promote the development of sound die-casting engineering for the benefit of the entire die-casting industry, established Subcommittee IX on Die-Casting Processes. The proposed work of the committee was to devise methods and instruments for the measurement of a number of factors involved in die casting, such as temperatures of the cover die, ejector die, and core surface; temperature in the metal chamber; plunger speed; metal pressure; also, to carry out these measurements.

The inadequacy of certain theoretical aspects of the die-casting process at the present time is indicated by H. H. Doehler in his book "Die Casting" (1)[2] as follows:

> There are three principal ways of controlling the shot speed of a die-casting machine:
>
> 1. By controlling the flow of hydraulic fluid in the input side of the hydraulic shot cylinder.
> 2. By controlling the hydraulic flow in the exhaust side of the hydraulic shot cylinder.
> 3. By changing the gate opening, thereby changing the metal flow which in turn controls the hydraulic flow.
>
> Other means, of course, can be employed, such as using a large or small diameter cylinder to speed up or slow down the shot. Naturally, this not only changes the speed of piston travel, but changes the force on the metal as well.

Up to the present time, however, there has been no direct correlation between any of those methods and (1) hydraulic pressures encountered while making the shot, or (2) the velocities of the shot mechanism while making a shot.

The purpose of this study was to demonstrate the interdependence of these variable factors, to introduce the venting of the die as an additional important factor, and to provide the mathematical framework for a working theory on die casting, coordinating all of these variables.

Such a working theory is indispensable for the planning of experimental work and for the proper "design of the experiment" in order to be able to generalize experimentally gained knowledge and to extend it to various conditions and types of die-casting machines.

Previous Research

The existing literature on die casting is quite voluminous. A very complete bibliography was compiled by James L. Erickson (2). Other important contributions have been made by Edward Jacobi (3), Alfred Bauer (4), W. J. During (5), and H. H. Doehler (1).

A survey of the die-casting literature discloses that it has, in the main, been concerned with an empirical description of the processes and the various types of die-casting machines; casting design and quality; die construction and die steels; economy features and the metallurgical aspects of the various die-casting alloys. Leopold Frommer (6) and Edward Jacobi (3) presented analytical approaches for calculating the metal velocity and the die-filling time. Both made the simplified assumption that the pressure in the die cavity is equal to atmospheric pressure during the filling period. Energy losses in the metal, drive, and return systems were neglected in Frommer's analysis, while Jacobi assumed steady-state conditions and introduced, insufficiently, only losses in the metal system. Because of these and other simplifications, the results bear little resemblance to actuality.

Frommer's conception, however, of the metal flow in a simple rectangular die cavity entering through a thin band gate extending across the width of one of the small sides of the rectangle, has been confirmed qualitatively by Koester and Goehring (7) who carried out die-casting experiments in Woods metal in a transparent mold and took pictures of the filling process with a camera capable of exposing up to 3500 frames per second. According to Frommer's conception, the liquid metal enters the die as a parallel jet and flows through the cavity in the shape and direction determined by the gate until it strikes the die wall opposite the gate. At the first contact with the die wall, a damming or banking-up action occurs, accompanied by swirls and eddies, and a part of the cavity next to this side is filled. As the pool increases, metal begins to flow out of it along the two side walls in the direction opposite the incoming jet. Frommer calls these return streams "forerunners" (Voreilung). Their thickness is theoretically one half of the gate thickness and their velocity decreases progressively because of friction and heat loss to the die. Within a short distance, the center pool catches up with the forerunners, and from this point on the cavity fills quite uniformly from the back toward the gate.

Quality Requirements for Satisfactory Die Castings

The technical requirements for satisfactory die castings include good surface quality, sharpness of outline, minimum porosity, and controlled mechanical and physical properties inherent in the alloy used.

In order to achieve these desired properties, the velocity of the metal entering the die must be sufficiently great to prevent its excessive cooling due to the high rate of heat extraction by the steel die. This is necessary in order to attain complete fusion of the various metal branches flowing together when the die filling is completed. Sharpness of outline will be enhanced further by the existence of a pressure during the die filling.

As to porosity, there are three causes for this in any casting:

1. Shrinkage due to difference in specific volumes of the molten metal at the liquidus temperature and the solidified metal at the solidus temperature.
2. Gases dissolved in the molten metal liberated during solidification.
3. Trapped cavity air.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

*This paper is an abridged presentation of a dissertation, sponsored by the Mechanical Engineering Department of Columbia University and accepted by the Faculty of Pure Science of Columbia University in partial fulfillment of the requirements for the Degree of Doctor of Philosophy.

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[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

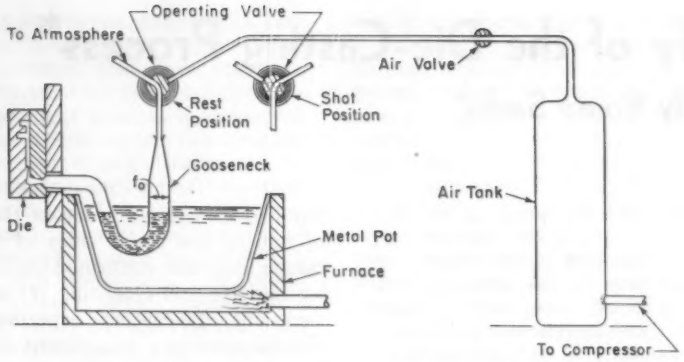

Fig. 1.—Direct-Air Gooseneck (Hot-Chamber) Machine.

Shrinkage:

Considering porosity due to shrinkage, assume the following three theoretically defined rates of solidification of a casting requiring no core for its production. First, it may solidify with infinitely slow speed, and then no porosity would occur. The casting would, theoretically, be sound. Its volume immediately after solidification would be smaller than the mold or die cavity by the full difference of the volumes of the liquid and solid metal. Second, it may solidify gradually and uniformly from the outside toward the inside. Then its volume immediately after solidification would be equal to the cavity volume, but a macro shrinkage pipe would be formed in the center. Third, it may solidify with infinitely great speed, that is, suddenly throughout its body. Then its volume after solidification would also be equal to the cavity. In this case, however, the shrinkage would manifest itself in infinitesimal and uniformly distributed porosity.

Actual production conditions fall between these extreme cases and are dependent upon the thermal conditions of the metal, the mold or die, and the lubricants, and also upon the shape and configuration of the castings. All of these determine the rate of heat flow and the rate and progress of solidification.

As a result of the thermal conductivity of steel dies, cooling and solidification in the die-casting process take place very rapidly as compared with castings made in sand molds. In properly designed die castings, the shrinkage is revealed as finely distributed, microscopically small intercrystalline interstices. This is a porosity pattern not detrimental to either the quality or properties of the product, and it does not cause practical difficulties for the die caster.

Gases:

Because of the rapid solidification rate in die casting, very little time, if any, is available for the dissolved gases in the molten metal to evolve out of solution during the cooling phase. This type of porosity is therefore much less prevalent in die castings than in sand castings.

Trapped Air:

This is the most serious cause of porosity in die castings, whereas it is insignificant in sand castings. In the pouring of sand castings, the velocities and forces are gravitational and very small indeed, compared with die-casting conditions. During pouring into a sand mold, the air in the mold cavity has ample time in which to rise above the level of the metal. The metal entering the mold displaces the air, which escapes through the porous mold material. In die casting, however, there are no communicating channels to the atmosphere for the escape of air from all points of the cavity surface. The die caster can provide, in the steel die, only a limited number of vent slots at selected locations, usually in the parting plane of the die and around cores and ejector pins. The filling of intricate die-casting dies at high velocity is so complicated that neither theoretical knowledge nor experimental data are sufficient to predict the exact flow pattern of the metal in the die cavity. The liquid metal rushes into the die as a parallel jet. It flows through the cavity in the shape and direction determined by the gate until it strikes a core or wall, causing a division of the jet into two or more branches. This occurrence multiplies as the branches impinge upon another core or on internal die surfaces. As the die becomes filled, all of the branches flow together and trap portions of the cavity air. This tendency to trap air is aggravated by the limitation in providing vent slots and by the successive reduction and closing of these vent slots as the filling process progresses.

Even in sand casting, a pressure increase in the mold during pouring takes place, although it is slight. This is due, first, to the fact that the air in the mold cavity receives heat from the incoming hot metal; second, to the fact that the sand mold offers a resistance to the flow of escaping gases. In the die-casting process, this pressure rise is much greater and its analysis has been made part of the present study.

Types of Die-Casting Machines

In most present-day die-casting machines, the velocity of the liquid metal is obtained from potential energy of a driving agent which is either (*a*) compressed air, acting directly upon the molten metal in the pressure chamber (gooseneck) of the die-casting machine (Fig. 1) or (*b*) compressed air or incompressible pressure fluid, acting in a cylinder on a piston, which in turn acts through a plunger on the molten metal in the pressure chamber of the die-casting machine (Figs. 2, 3, and 4).

In every die-casting machine, there are four systems (except in direct-air gooseneck machines, having only three), which act simultaneously. These are:

1. The drive system, consisting of (*a*) in plunger machines, pressure fluid

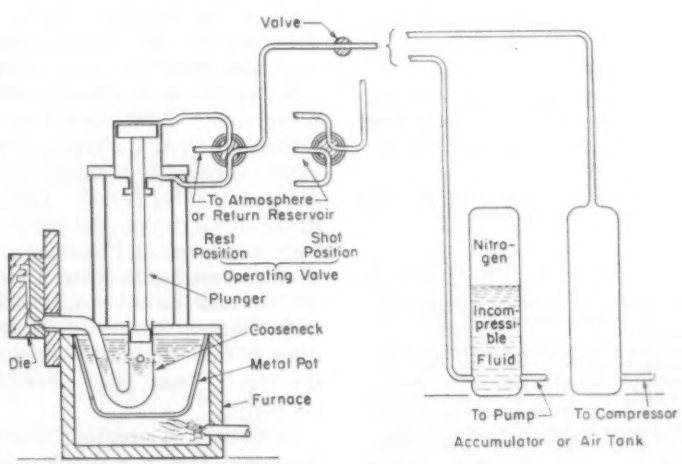

Fig. 2.—Plunger-Type Gooseneck (Hot-Chamber) Machine.

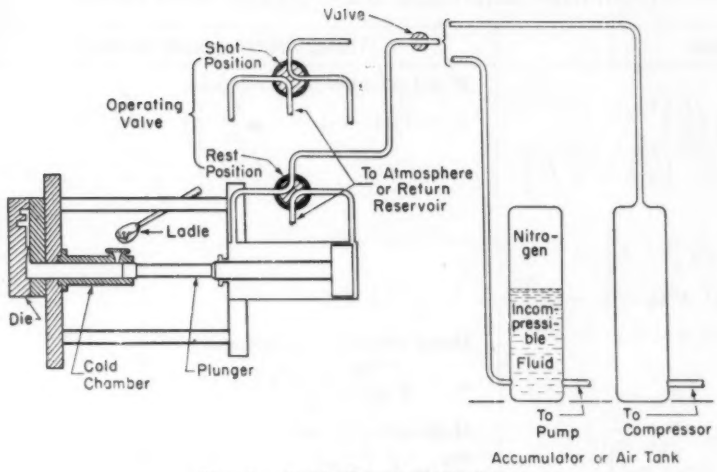

Fig. 3.—Cold-Chamber Machine.

or compressed air (in accumulator or tank, in drive pipe line and drive cylinder), piston and plunger, or (*b*) in direct-air gooseneck machines, compressed air in tank, drive pipe line, and gooseneck.

2. The return system, consisting in plunger machines of pressure fluid or compressed air in return cylinder and return pipe line.

3. The metal system, consisting of metal contained in the gooseneck or cold chamber.

4. The air cavity system, consisting of air in the die cavity and its accesses.

Method of Solution

Based on fundamental laws of mechanics, hydro- and thermodynamics, a system of equations has been developed to describe (in terms of geometrical and physical quantities pertaining to the die-casting machine, the die and metal) the process of die casting, and the resulting porosity of the casting. In doing so, the following factors have been accounted for: mechanical friction and flow losses in the machine, drive, return, metal and cavity-air systems; inertia forces; opening period of the operating valve; and venting conditions in the die. Thus, the die-casting operation has been followed with as few simplifications as possible.

The following table shows the factors considered in this study in comparison with previous analytical research work:

Factors Considered	Frommer (6)	Jacobi (3)	Sachs
Drive System			
Inertia forces	x	...	x
Losses	...	...	x
Influence of opening period of operating valve	...	...	x
Return System			
Inertia forces	...	...	x
Losses	...	...	x
Influence of opening period of operating valve	...	...	x
Metal System			
Inertia forces	x	...	x
Losses	...	x	x
Air System (Venting)	...	...	x

An exact three-dimensional analysis, because of its complexity, does not lead to analytical and usable solutions. Therefore, the four systems were considered as unidimensional. Such a simplification is accepted in applied fluid dynamics, provided the velocities in the x direction are predominant and provided the influence of the relatively small y and z velocity components is accounted for by the use of coefficients. These conditions do exist in die casting and have been complied with in this study.

Numerical values in all calculations throughout are in pounds, feet, and seconds. All pressures used in the calculations are gage pressures except atmospheric pressure, designated as p_{at}, which is absolute.

Delimitation:

The problem of solidification of the metal in the die was not analyzed quantitatively in this study. It is discussed however, in connection with recommendations as to further research work.

Analysis of the Die-Casting Operation

It is necessary to consider the die-casting operation, or "shot," which takes place in a transient state condition, in several—at least three—steps or periods.

The metal starts from rest and the shot is initiated by actuating the operating value. During the opening period of the valve, its resistance varies from infinity at time $t = 0$ and position $x = 0$ to ζ_{v_0}, when fully opened. In most cold-chamber machines, the first portion of the shot is simultaneously slowed down further until the plunger has covered the pouring slot in order to prevent the metal from splashing out of the pouring slot as a result of the surface wave caused by the sudden acceleration. This slowing down of the plunger is achieved by a design having the position at $x = 0$ almost completely closing the pipe inlet into the cylinder and by the provision of a shunt feed of very small diameter (Fig. 5). This shunt feed represents additional resistance in the

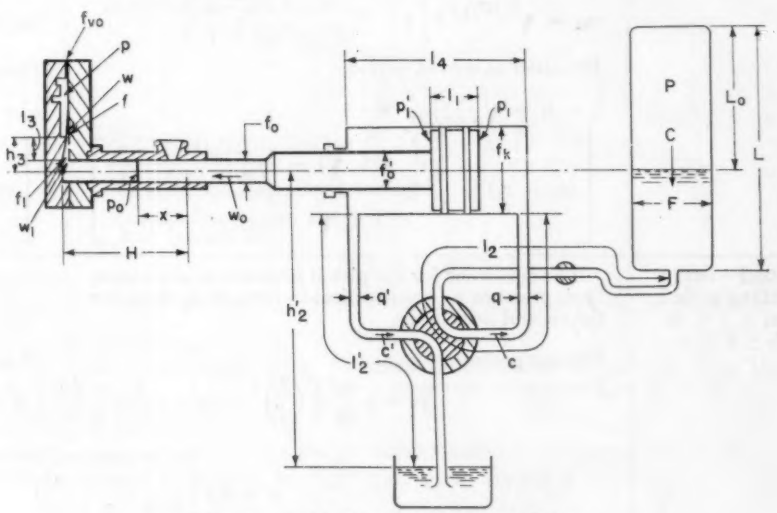

Fig. 4.—Cold-Chamber Machine Setup.

x = plunger displacement at time t, measured from plunger start $x = 0$, $t = 0$
F = area of accumulator
f_k = area of piston
f_s' = area of piston rod
f_o = area of plunger
f_1 = area of gate entrance
f = area of gate exit
f_{vo} = area of vent slots in die
q = area of drive pipe line
q' = area of return pipe line
P = pressure in accumulator
p_1 = pressure on piston area f_k
p_1' = pressure on piston area $(f_k - f_o')$
p_o = pressure on plunger area f_o
p = pressure of air in die cavity
L = length of accumulator
L_o = height of nitrogen in accumulator at $t = 0$
l_2 = length of drive pipe line
l_2' = length of return pipe line
l_1 = length of piston
l_3 = length of gate
l_4 = length of cylinder
h_2' = height of plunger axis above reservoir level
h_3 = height of gate exit above plunger axis
H = distance of plunger at $x = 0$ to ejector half of die
C = velocity of drive fluid in accumulator
c = velocity of drive fluid in drive pipe line
c' = velocity of drive fluid in return pipe line
w_o = velocity of piston
w_1 = velocity of metal in gate entrance
w = velocity of metal in gate exit

TABLE I.—MATHEMATICAL RELATIONSHIPS BETWEEN DIE-CASTING VARIABLES.

Period	Plunger Machines	Direct Air Gooseneck Machines
First period, $0 \leq x \leq x_1$ $0 \leq t \leq t_1$	Piston pressure, $p_1 = P_0(1 - \alpha x) - \rho \frac{w_0^2}{2g}\left[1 + \zeta\left(\frac{f_k}{q}\right)^2 \frac{x_1}{x} - \left(\frac{f_k}{F}\right)^2\right] - \frac{\rho}{g}\frac{dw_0}{dt}\left[\left(\frac{f_k}{q}\right) l_2 + x + \left(\frac{f_k}{F}\right)(L - L_0)\right]$ Piston back pressure, $p_1' = \rho \frac{w_0^2}{2g}\left[\left(\frac{f_k - f_0'}{q'}\right)^2 (1 + \zeta')\frac{x_1}{x} - 1\right] - \rho h_2' + \frac{\rho}{g}\frac{dw_0}{dt}\left[\left(\frac{f_k - f_0'}{q'}\right) l_2' + (l_4 - l_1 - x)\right]$ Plunger velocity, $w_0 = \sqrt{\frac{(2/A_1)0.97 f_k P_0}{(2C_1x_1/A_1) + 1}}\, x$ Plunger acceleration, $\frac{dw_0}{dt} = \frac{1}{A_1}\left[0.97 f_k P_0(1 - \alpha x) - C_1 x_1 \frac{1}{x} w_0^2\right]$ Plunger velocity at $x = x_1$, $w_{01} = \sqrt{\frac{(2/A_1)0.97 f_k P_0}{(2C_1x_1/A_1) + 1}}\, x_1$ Duration of first period, $t_1 = 2\sqrt{\frac{(2C_1x_1/A_1) + 1}{(2/A_1)0.97 f_k P_0}}\, x_1$	Metal pressure in gooseneck, $p_0 = P_0(1 - \alpha x) - \rho \frac{w_0^2}{2g}\left[1 + \zeta\left(\frac{f_0}{q}\right)^2 \frac{x_1}{x} - \left(\frac{f_0}{F}\right)^2\right] - \frac{\rho}{g}\frac{dw_0}{dt}\left[\left(\frac{f_0}{q}\right) l_2 + x\right]$ Metal velocity in gooseneck, $w_0 = \sqrt{\frac{(2/A_1) f_0 P_0}{(2C_1x_1/A_1) + 1}}\, x$ Metal acceleration in gooseneck, $\frac{dw_0}{dt} = \frac{1}{A_1}\left[f_0 P_0(1 - \alpha x) - C_1 x_1 \frac{1}{x} w_0^2\right]$ Metal velocity in gooseneck at $x = x_1$, $w_{01} = \sqrt{\frac{(2/A_1) f_0 P_0}{(2C_1x_1/A_1) + 1}}\, x_1$ Duration of first period, $t_1 = 2\sqrt{\frac{(2C_1x_1/A_1) + 1}{(2/A_1) f_0 P_0}}\, x_1$
Second period, $x_1 \leq x \leq x_2$ $t_1 \leq t \leq t_2$	The equations for the piston pressure p_1 and piston back pressure p_1' are identical in form with those of the first period, the only exception being that the factor x_1/x (coming from the varying resistance of the operating valve) is now $x_1/x_1 = 1$. Plunger velocity, $w_0 = \sqrt{\frac{0.97 f_k P_0}{C_1}\left[1 - \frac{e^{-(2C_1/A_1)(x - x_1)}}{(2C_1x_1/A_1) + 1}\right]}$ Plunger acceleration, $\frac{dw_0}{dt} = \frac{1}{A_1}\left[0.97 f_k P_0(1 - \alpha x) - C_1 w_0^2\right]$ Plunger velocity at $x = x_2$, $w_{02} = \sqrt{\frac{0.97 f_k P_0}{C_1}\left[1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}\right]}$ Duration of second period, $t_2 - t_1 = \sqrt{\frac{C_1}{0.97 f_k P_0}} \times \left[(x_2 - x_1) + \frac{A_1}{C_1} lg \frac{1 + \sqrt{1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}}}{1 + \sqrt{1 - \frac{1}{(2C_1x_1/A_1) + 1}}}\right]$	The equation for the metal pressure in the gooseneck, p_0, is identical in form with that for the first period, the only exception being that the factor x_1/x is now 1. Metal velocity in gooseneck, $w_0 = \sqrt{\frac{f_0 P_0}{C_1}\left[1 - \frac{e^{-(2C_1/A_1)(x - x_1)}}{(2C_1x_1/A_1) + 1}\right]}$ Metal acceleration in gooseneck, $\frac{dw_0}{dt} = \frac{1}{A_1}\left[f_0 P_0(1 - \alpha x) - C_1 w_0^2\right]$ Metal velocity in gooseneck at $x = x_2$, $w_{02} = \sqrt{\frac{f_0 P_0}{C_1}\left[1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}\right]}$ Duration of second period, $t_2 - t_1 = \sqrt{\frac{C_1}{f_0 P_0}} \times \left[(x_2 - x_1) + \frac{A_1}{C_1} lg \frac{1 + \sqrt{1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}}}{1 + \sqrt{1 - \frac{1}{(2C_1x_1/A_1) + 1}}}\right]$
Actual cavity filling period, $x_2 \leq x < x_3$ $t_2 \leq t \leq t_3$	The equations for the piston pressure p_1 and piston back pressure p_1' are identical in form with those for the second period. Plunger pressure, $p_0 = \gamma \frac{w_0^2}{2g}\left[\left(\frac{f_0}{f}\right)^2 + \zeta_0 - 1\right] + \frac{\gamma}{g}\frac{dw_0}{dt}\left[H - x + f_0 \int_0^{l_3} \frac{d\xi}{f_x}\right] + \gamma h_3 + p$ Air pressure in die cavity, $p = p_{at}\left[\frac{1}{0.53}\left(\frac{x_3 - x_2}{x_3 - x}\right)^{(7/5)(1 - n)} - 1\right]$ Venting factor, $n = \frac{18.6 f_{v0}\sqrt{T_1}}{f_0 w_{02}'}$ Optimum total vent area, $f_{v0} = \frac{f_0 w_{02}'}{20.6\sqrt{T_1}}$	Metal pressure in gooseneck, $p_0 = \gamma \frac{w_0^2}{2g}\left[\left(\frac{f_0}{f}\right)^2 + \zeta_0 - 1\right] + \frac{\gamma}{g}\frac{dw_0}{dt}\left[H - x + f_0 \int_0^{l_3} \frac{d\xi}{f_x}\right] + \gamma h_3 + p$ Air pressure in die cavity, $p = p_{at}\left[\frac{1}{0.53}\left(\frac{x_3 - x_2}{x_3 - x}\right)^{(7/5)(1 - n)} - 1\right]$ Venting factor, $n = \frac{18.6 f_{v0}\sqrt{T_1}}{f_0 w_{02}'}$ Optimum total vent area, $f_{v0} = \frac{f_0 w_{02}'}{20.6\sqrt{T_1}}$

Plunger velocity,

$$w_0 = \sqrt{\frac{B}{C_2}}\left\{1 + \left[\frac{C_2}{[1 - (\alpha/2)(x_3 + x_2) - \beta]C_1}\left(1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}\right) - 1\right] e^{-(2C_2/A_2)(x - x_2)}\right\}$$

Metal velocity in gooseneck,

Velocity of metal entering the die cavity,

$$w = \frac{f_0}{f} w_0$$

Plunger deceleration (acceleration),

$$\frac{dw_0}{dt} = \frac{1}{A_2}(B - C_2w_0^2)$$

Metal deceleration in gooseneck,

Duration of actual cavity filling period,

$$t_3 - t_2 = \sqrt{\frac{C_2}{B}} \times \left\{(x_3 - x_2) + \frac{A_2}{C_2} lg \frac{1 + \sqrt{1 + \left[\frac{C_2}{[1 - (\alpha/2)(x_3 + x_2) - \beta]C_1}\left(1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}\right) - 1\right] e^{-(2C_2/A_2)(x_3 - x_2)}}}{1 + \sqrt{1 + \left[\frac{C_2}{[1 - (\alpha/2)(x_3 + x_2) - \beta]C_1}\left(1 - \frac{e^{-(2C_1/A_1)(x_2 - x_1)}}{(2C_1x_1/A_1) + 1}\right) - 1\right]}}\right\}$$

Mean static force acting on piston plunger,

$$B = 0.97f_kP_0\left[1 - \frac{\alpha}{2}(x_3 + x_2) - \beta\right]$$

Mean static force acting on metal in gooseneck,

$$B = f_0P_0\left[1 - \frac{\alpha}{2}(x_3 + x_2) - \beta\right]$$

Cavity air pressure factor,

$$\beta = \frac{1 - \alpha x_3}{(7/5)(1 - n) - 1}m - \frac{f_0(1 + 1.15\mu_0)p_{at}}{0.97f_k(P_0 + p_{at})}\left[\frac{1}{0.53[(7/5)(1 - n) - 1]} + 1\right]$$

Cavity air pressure factor,

$$\beta = \frac{1 - \alpha x_3}{(7/5)(1 - n) - 1}m - \frac{p_{at}}{P_0 + p_{at}}\left[\frac{1}{0.53[(7/5)(1 - n) - 1]} + 1\right]$$

Porosity,

$$m = \left[\frac{1}{0.53}\frac{f_0(1 + 1.15\mu_0)p_{at}}{0.97f_k[P_0(1 - \alpha x_3) + p_{at}]}\right]^{\frac{1}{\frac{7}{5}(1 - n)}}$$

Porosity,

$$m = \left[\frac{1}{0.53}\frac{p_{at}}{P_0(1 - \alpha x_3) + p_{at}}\right]^{\frac{1}{\frac{7}{5}(1 - n)}}$$

Independent of period

Machine characteristics,

$$C_1 = \left\{\frac{\rho}{2g}\frac{1}{q^2}\left[(1.03f_k - 0.88f_0')(f_k - f_0')^2(1 + \zeta') + 0.97f_k^3\zeta\right]\right\}$$

$$A_1 = \left\{\frac{\rho}{g}\frac{1}{q}\left[(1.03f_k - 0.88f_0')(f_k - f_0')l_2' + 0.97f_k^2l_2\right] + \frac{G}{g}\right\}$$

Machine characteristics,

$$C_1 = \left\{\frac{\rho}{2g}\left(\frac{f_0^2}{q^2}\right)\zeta\right\}$$

$$A_1 = \left\{\frac{\rho}{g}\frac{f_0^2}{q}l_2\right\}$$

Metal system characteristics,

$$C_0 = \left\{\frac{\gamma}{2g}f_0(1 + 1.15\mu_0)\left[\left(\frac{f_0}{f}\right)^2 + \zeta_0 - 1\right]\right\}$$

$$A_0 = \left\{\frac{\gamma}{g}f_0(1 + 1.15\mu_0)\left[H + f_0\int_0^{l_3}\frac{d\xi}{f_x}\right]\right\}$$

Metal system characteristics,

$$C_0 = \left\{\frac{\gamma}{2g}f_0\left[\left(\frac{f_0}{f}\right)^2 + \zeta_0 - 1\right]\right\}$$

$$A_0 = \left\{\frac{\gamma}{g}f_0\left[H + f_0\int_0^{l_3}\frac{d\xi}{f_x}\right]\right\}$$

Accumulator (or tank) factor,

$\alpha = \frac{1.4f_k}{FL_0}$ (or $\frac{1.4f_k}{FL}$)

Tank factor,

$\alpha = \frac{1.4f_0}{FL}$

f_0 = area of plunger

f_0 = area of gooseneck

μ_0 = plunger friction coefficient

P_0 = pressure in accumulator (or tank) at the beginning of the shot

P_0 = pressure in air tank at the beginning of the shot

G = weight of piston, piston rod, and plunger

x = plunger displacement at time t measured from start $x = 0$, $t = 0$

x = metal displacement in gooseneck at time t measured from start $x = 0$, $t = 0$

ζ' = sum of resistance coefficients of all resistances in return system, referred to velocity c'

w_{02}' = plunger velocity at $x = x_2'$

w_{02}' = metal velocity in gooseneck at $x = x_2'$

F, f_k, f_0', f_1, f, f_{v0}, q, q', P, L, L_0, l_2, l_2', l_1, l_3, l_4, h_2, h_3, H, C, c, c', w_1, w, see Fig. 4

g = gravity acceleration

e = base of natural logarithm

ρ = density of driving agent

γ = density of molten metal

ζ = sum of resistance coefficients of all resistances in drive system, referred to velocity c

ζ_0 = sum of resistance coefficients of all resistances in metal system, referred to velocity w_0

T_1 = absolute temperature of air for position $x = x_1$ (which lies between the absolute metal temperature T_m and absolute die temperature T_d)

f_x = area of gate section at distance ξ from gate entrance (see Fig. 7*b*)

ξ = distance of gate section f_x from gate entrance (see Figs. 7(*a*) and 7(*b*)

$C_2 = C_1 + C_0$

$A_2 = A_1 + A_0$

drive system during the first period, that is, until the plunger reaches the position $x = x_1$ (Fig. 6). Referring to Fig. 6 and with: V_c = volume of casting, V_g = volume of gate, V_r = volume of residue, and V_t = total metal volume ($= V_c + V_g + V_r$), the subsequent periods are defined as follows:

second period:

$$\text{from } \begin{cases} x = x_1 \\ t = t_1 \\ w_0 = w_{01} \end{cases} \text{ to } \begin{cases} x = x_2 = H - V_t/f_0 \\ t = t_2 \\ w_0 = w_{02} \end{cases}$$

third period:

$$\text{from } \begin{cases} x = x_2 \\ t = t_2 \\ w_0 = w_{02} \end{cases} \text{ to } \begin{cases} x = x_2' = x_2 + V_g/f_0 = H - \dfrac{V_t - V_g}{f_0} \\ t = t_2' \end{cases}$$

fourth period, actual cavity filling:

$$\text{from } \begin{cases} x = x_2' \\ t = t_2' \end{cases} \text{ to } \begin{cases} x = x_3 = x_2' + \dfrac{V_c}{f_0} = H - \dfrac{V_t - V_g - V_c}{f_0} = H - \dfrac{V_r}{f_0} \\ t = t_3 \end{cases}$$

The third period is extremely short as compared with the others. Therefore, it is not being treated separately, but as though belonging to the actual cavity filling, thus changing the latter's boundary condition to:

$$\text{from } \begin{cases} x = x_2 \\ t = t_2 \\ w_0 = w_{02} \end{cases} \text{ to } \begin{cases} x = x_3 = x_2 + \dfrac{V_g + V_c}{f_0} = H - \dfrac{V_t - V_g - V_c}{f_0} = H - \dfrac{V_r}{f_0} \\ t = t_3 \end{cases}$$

The space required for the derivations of the mathematical relationships (8) between the various die-casting variables exceeds that available for this article. Therefore, only the resultant final equations are reported here, see Table I.

Valve, Fitting, and Pipe-Line Resistances:

In order to convert these equations into practical forms, it is necessary to introduce numerical values for the various resistances. The resistance coefficients of the pipe lines, fittings, standard valves, entrance and sudden contractions are taken from widely accepted published data (9,10,11).

The resistance coefficient ζ_{v_0} of the four-way operating valve in the fully open position is derived from data given in a communication of June, 1949, from the Vickers, Inc., Division of Sperry Corp., Detroit, whose valves are used in a great number of hydraulically driven die-casting machines.

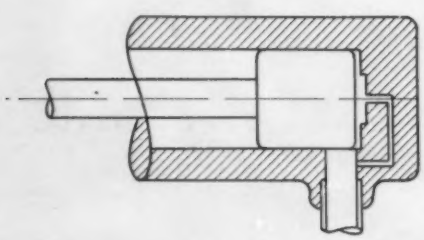

Fig. 5.—Shunt Feed in Drive Cylinder.

Gate Resistance and Metal Viscosity:

As to the gate resistance ζ_g (referred to w_0), no standard published data exist that would be applicable. Hence it becomes necessary to develop a suitable expression for this. The gates employed in actual die-casting practice may be considered as being represented by Fig. 7(*a*) or as being composed of bodies of the outline shown in this figure. While Fig. 7(*a*) shows the side *a* as being greater than a_1, it is intended to be interpreted to include such cases where the side *a* is smaller than a_1. The formula which follows is valid for all values of *a* and *b*, $a \gtrless a_1$, and $b \gtrless b_1$:

$$\zeta_g = \frac{\lambda}{2} f_0^2 l_2 \left\{ \frac{1}{(a_1 b - a b_1)^4} \left[3(a-a_1)^2(b-b_1) - 3(a-a_1)(b-b_1)^2 \right] lg \frac{a_1 b}{a b_1} - \frac{1}{(a_1 b - a b_1)^3} \left[\frac{(a-a_1)^3 - 2(a-a_1)^2(b-b_1)}{a a_1} + \frac{2(a-a_1)(b-b_1)^2 - (b-b_1)^3}{b b_1} \right] + \frac{1}{(a_1 b - a b_1)^2} \left[\frac{(b-b_1)^2(b+b_1)}{2b^2 b_1^2} + \frac{(a-a_1)^2(a+a_1)}{2a^2 a_1^2} \right] \right\}$$

λ in the above equation is a function of the Reynolds number

$$Re = \frac{d_x w_x}{\nu}$$

where $d_x = 4(f_x/u_x)$ = hydraulic diameter of section f_x (Fig. 7(*b*)), and ν = kinematic viscosity of the liquid metal. The kinematic viscosity ν is viscosity η divided by mass density, or $\nu = \frac{\eta g}{\gamma}$. The viscosity η of metals and alloys closely above their liquidus point is of the same order of magnitude as that of water (12,13). Hence, the kinematic viscosity of metals, because of their greater mass density, is even less than that of water. The investigation by Saito and Matsukawa (13) determined the kinematic viscosity of the eutectic aluminum-silicon alloy (12.7 per cent Si), which is a standard die-casting alloy, as 0.01 sq cm per sec at 580 C (melting point is 577 C), and 0.011 sq cm per sec at 650 C. This is indeed practically identical to the viscosity of water.

With a kinematic viscosity of this magnitude, the Reynolds numbers in the gate during the cavity-filling period are between 1×10^5 and 4×10^5. The corresponding values of λ lie between 0.018 and 0.0125 according to the Blasius formula (14) which is:

$$\lambda = 0.3164 \sqrt[4]{\frac{1}{Re}}$$

and between 0.018 and 0.013 according to the Jacob and Erk formula (15) which is:

$$\lambda = 0.00714 + 0.614 R_e^{-0.35}$$

It will thus be seen that for the present range of Reynolds numbers, λ by either the Blasius formula or that by Jacob and Erk is substantially the same.

In the present calculations, a constant mean value of $\lambda = 0.016$ is used.

Gate Entrance Resistance:

Another resistance coefficient requiring special consideration is the one representing the loss in the bend at the gate entrance, designated at ζ_b and referred to the velocity w_0. This resistance coefficient can be estimated from Fig. 8, taken from experiments by Nippert (16) as:

$$\zeta_b = \zeta_a \left(\frac{f_0}{f_1} \right)^2$$

where ζ_a = resistance coefficient of bend referred to w_1.

It follows from Fig. 8 that for each inside radius r_i there exists an optimum outside radius r_a. This optimum becomes the more pronounced—and for practical gate design the more important—the smaller the r_i.

ASTM Test Casting and Die-Casting Machines

The equations in Table I now make it possible to calculate the metal and hydraulic pressures, the velocities of the shot mechanism, the die filling time, and porosity of a casting, and to demonstrate their dependence upon the various factors entering the die-casting process.

Table II and Fig. 9 show the results of these calculations as applied to the ASTM Committee B-6 test casting, Fig. 10, produced under equivalent thermal condition in aluminum alloy No. 13 (approximately 13 per cent Si) with four different gate thicknesses, 0.030, 0.040, 0.050, and 0.060 in., on eleven different die-casting machines specified in Table III.

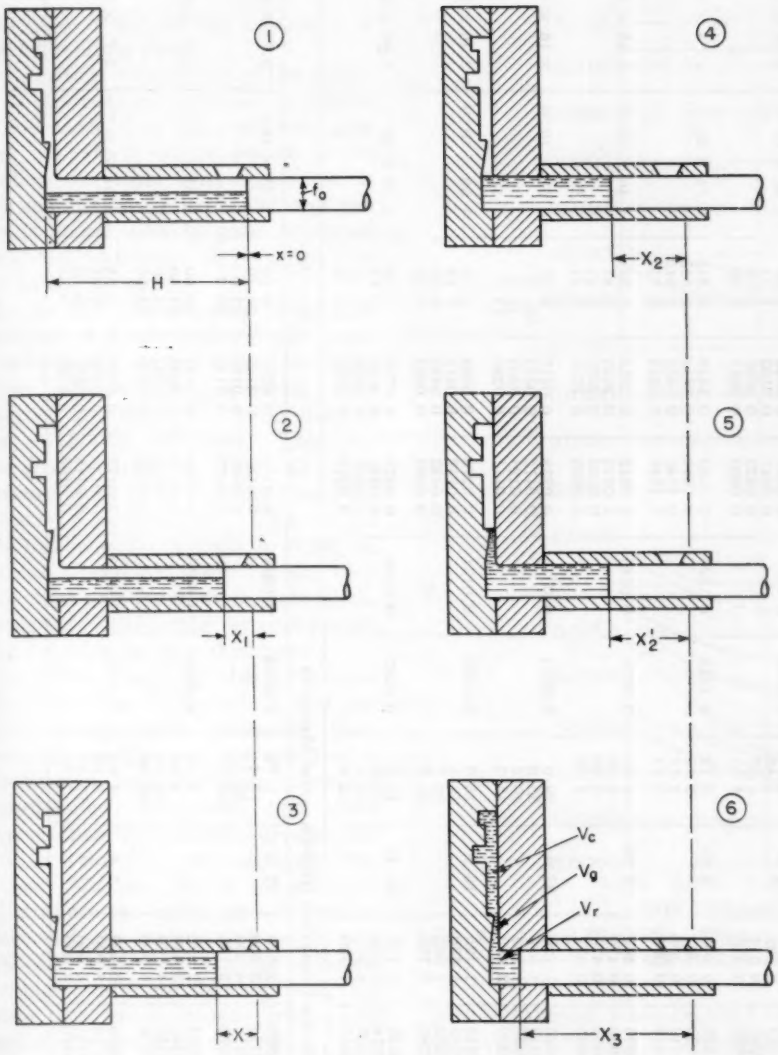

Fig. 6.—Plunger Positions in Cold Chamber.

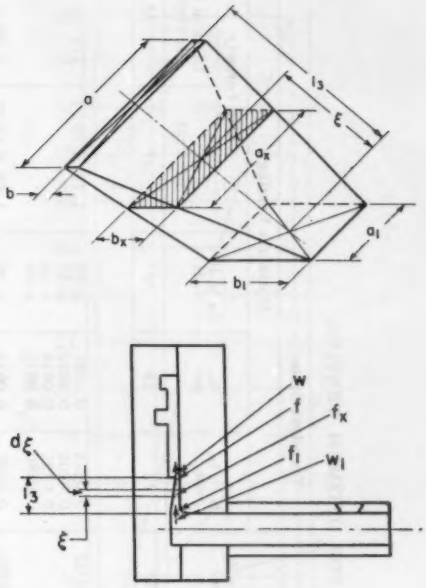

Fig. 7.—Shape of Gate.

Machines Nos. 1 to 7 are cold-chamber machines; Nos. 8, 9, and 10, direct-air gooseneck (hot-chamber) machines. Machines Nos. 1 and 1*a* are identical, with the exception of the starting pressure in the accumulator which is 2000 and 1000 psi, respectively. Machines Nos. 1*a* and 2 are identical, with the exception of the diameters of the pipe lines which are 2 and $1\frac{1}{4}$ in., respectively. Machines Nos. 2 and 3 are identical, with the exception of the piston diameters which are 4 and 5 in., respectively. Machines Nos. 4 and 1*a* are identical, with the exception of the piston diameters which are 6 and 4 in., respectively.

Machines Nos. 5, 6, and 7 are identical with machines Nos. 1*a*, 2, and 3, except that machines Nos. 1*a*, 2, and 3 are hydraulically driven while machines Nos. 5, 6, and 7 are air operated.

The direct-air gooseneck machines Nos. 8, 9, and 10 are identical, with the exception of the diameters of the pipe line, which are 2, $1\frac{1}{4}$, and $\frac{3}{4}$ in., respectively.

Effect of Machine Characteristics, Gate Thickness, and Vent Area:

For the casting under investigation, the minimum porosity *m*, column 17, Table II, is the smallest obtainable with the respective machines. In column 18, this porosity is presented as the diameter of a single spherical blowhole. It can be seen that it is negligible in castings made on machines Nos. 1 to 7 and very small (0.0037 in.) in castings made on the direct-air gooseneck (hot-chamber) machines Nos. 8 to 10. This minimum porosity, however, can be obtained only under optimum venting conditions, that is, with vent areas shown in column 16, Table II. For machine No. 10, for instance, these vent areas are 5.58×10^{-4}, 7.55×10^{-4}, 8.60×10^{-4}, and 9.30×10^{-4} sq ft for gate thicknesses of 0.030, 0.040, 0.050, and 0.060 in., respectively. The largest total vent area that can be provided practically in the die under consideration is about 5×10^{-4} sq ft. With this value for the vent area, the porosities *m* for machine No. 10 and the diameters of a single spherical blowhole, also of 10, 20, and 50 spherical blowholes, are shown in Table IV.

While the casting produced with a gate thickness of 0.030 in. may still be just acceptable, greater gate thicknesses will result in entirely unsatisfactory castings. The porosity can be improved by throttling the air valve, Fig.

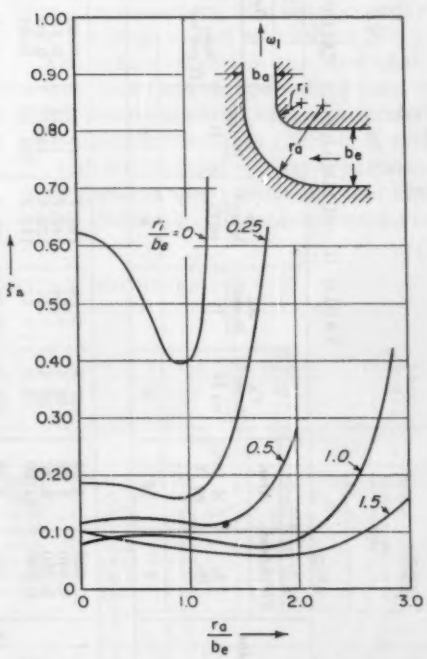

Fig. 8.—Resistance Coefficient of Bend, ζ_a, Referred to Velocity, w_1.

TABLE II.—SUMMARY OF CALCULATED CASTING AND OPERATING CONDITIONS FOR OPTIMUM VENTING.

Machine	Gate		C_3, lb-sec² / sq ft	A_3, lb-sec² / ft	C_2, lb-sec² / sq ft	A_2, lb-sec² / ft	Steady State			Transient State								
	Thickness	Area					Optimum Venting							Optimum Venting				
																	Min Porosity	
	b, in.	$f \times 10^4$, sq ft					w_{cst}, ft per sec	$t_3 - t_2$, sec	$f_{v3} \times 10^4$, sq ft	w_{21}, ft per sec	w_{22}', ft per sec	t_1, sec	$t_2 - t_1$, sec	$t_3 - t_2$, sec	t_3, sec	$f_{v3} \times 10^4$, sq ft	m, per cent	Diam of Single Blowhole, in.
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Cold-Chamber Machines																		
No. 1..	0.030	5.59	107.5	0.36	190.7	14.16	7.20	0.0390	1.185	13.95	15.1	0.0240	0.0187	0.0234	0.0661	4.52	1.78×10^{-15}	7.1×10^{-6}
	0.040	7.35	59.5	0.34	142.7	14.14	8.35	0.0335	1.365		16.0			0.0205	0.0632	4.80		
	0.050	9.30	39.4	0.33	122.6	14.13	9.00	0.0311	1.480		16.3			0.0191	0.0618	4.88		
	0.060	11.20	28.0	0.32	111.2	14.12	9.50	0.0295	1.560		16.5			0.0186	0.0613	4.95		
No. 1a..	0.030	5.59	107.5	0.36	193.7	14.16	5.10	0.0510	0.925	9.90	10.90	0.0336	0.0265	0.0337	0.0938	3.26	1.58×10^{-13}	3.16×10^{-5}
	0.040	7.35	59.5	0.34	142.7	14.14	5.90	0.0475	1.065		11.30			0.0289	0.0890	3.38		
	0.050	9.30	39.4	0.33	122.6	14.13	6.40	0.0438	1.158		11.55			0.0271	0.0872	3.45		
	0.060	11.20	28.0	0.32	111.2	14.12	6.75	0.0415	1.220		11.70			0.0261	0.0862	3.51		
No. 2..	0.030	5.59	107.5	0.36	688.5	31.96	2.70	0.1065	0.490	4.22	4.35	0.0790	0.0671	0.0661	0.2122	1.30	1.58×10^{-13}	3.16×10^{-5}
	0.040	7.35	59.5	0.34	640.5	31.94	2.78	0.1050	0.502		4.45			0.0641	0.2102	1.33		
	0.050	9.30	39.4	0.33	620.4	31.93	2.85	0.0985	0.514		4.57			0.0632	0.2093	1.37		
	0.060	11.20	28.0	0.32	609.0	31.92	2.86	0.0980	0.516		4.65			0.0600	0.2061	1.39		
No. 3..	0.030	5.59	107.5	0.36	2687	86.46	1.72	0.1625	0.300	2.61	2.72	0.1275	0.1120	0.1040	0.3435	0.815	5.76×10^{-15}	1.04×10^{-6}
	0.040	7.35	59.5	0.34	2639	86.44	1.73	0.1620	0.302		2.72			0.1040	0.3435	0.815		
	0.050	9.30	39.4	0.33	2619	86.43	1.74	0.1610	0.304		2.72			0.1040	0.3435	0.815		
	0.060	11.20	28.0	0.32	2608	86.42	1.74	0.1610	0.304		2.72			0.1040	0.3435	0.815		
No. 4..	0.030	5.59	107.5	0.36	1367	75.86	2.87	0.0975	0.463	4.30	4.60	0.0776	0.0640	0.0642	0.2058	1.38	4.46×10^{-16}	4.45×10^{-6}
	0.040	7.35	59.5	0.34	1319	75.84	2.92	0.0960	0.470		4.70			0.0610	0.2026	1.41		
	0.050	9.30	39.4	0.33	1299	75.83	2.95	0.0950	0.476		4.70			0.0605	0.2021	1.41		
	0.060	11.20	28.0	0.32	1288	75.82	2.96	0.0945	0.477		4.70			0.0600	0.2016	1.41		
No. 5..	0.030	5.59	107.5	0.36	110.4	3.38	6.75	0.0415	1.220	32.0	29.0	0.0104	0.0075	0.0238	0.0417	8.67	1.58×10^{-13}	3.16×10^{-5}
	0.040	7.35	59.5	0.34	62.4	3.36	8.95	0.0313	1.620		36.6			0.0172	0.0351	11.0		
	0.050	9.30	39.4	0.33	42.3	3.35	10.85	0.0258	1.960		40.5			0.0124	0.0303	12.1		
	0.060	11.20	28.0	0.32	30.9	3.34	12.75	0.0220	2.300		43.5			0.0111	0.0290	13.0		
No. 6..	0.030	5.59	107.5	0.36	127.6	4.00	6.25	0.0448	1.125	19.90	15.9	0.0168	0.0131	0.0270	0.0569	4.75	1.58×10^{-13}	3.16×10^{-5}
	0.040	7.35	59.5	0.34	79.6	3.98	7.90	0.0355	1.430		19.3			0.0212	0.0511	5.78		
	0.050	9.30	39.4	0.33	59.5	3.97	9.25	0.0302	1.662		20.7			0.0183	0.0482	6.20		
	0.060	11.20	28.0	0.32	48.1	3.96	9.85	0.0285	1.768		21.7			0.0164	0.0463	6.50		
No. 7..	0.030	5.59	107.5	0.36	196.5	6.36	6.36	0.0440	1.116	13.45	11.8	0.0247	0.0206	0.0276	0.0729	3.53	5.76×10^{-15}	1.04×10^{-6}
	0.040	7.35	59.5	0.34	148.5	6.34	7.40	0.0378	1.290		13.0			0.0241	0.0694	3.88		
	0.050	9.30	39.4	0.33	128.4	6.33	7.85	0.0357	1.375		13.5			0.0225	0.0678	4.04		
	0.060	11.20	28.0	0.32	117.0	6.32	8.20	0.0341	1.430		13.8			0.0216	0.0669	4.12		
Direct-Air Gooseneck (Hot-Chamber) Machines																		
No. 8..	0.030	5.59	334.0	0.36	335.4	0.53	2.79	0.0250	2.630	57.5	5.72	0.0058	0.0012	0.0155	0.0225	6.89	2.51×10^{-7}	3.7×10^{-3}
	0.040	7.35	185.0	0.34	186.4	0.51	3.72	0.0188	3.500		13.4			0.0115	0.0185	16.10		
	0.050	9.30	123.0	0.33	124.4	0.50	4.56	0.0153	4.300		22.5			0.0089	0.0159	27.0		
	0.060	11.20	85.3	0.32	86.7	0.49	5.48	0.0128	5.180		30.2			0.0073	0.0143	36.2		
No. 9..	0.030	5.59	334.0	0.36	343.8	0.79	2.75	0.0254	2.590	24.0	5.50	0.0139	0.0030	0.0158	0.0327	6.60	2.51×10^{-7}	3.7×10^{-3}
	0.040	7.35	185.0	0.34	194.8	0.77	3.65	0.0192	3.440		9.80			0.0116	0.0285	11.80		
	0.050	9.30	123.0	0.33	132.8	0.76	4.41	0.0158	4.160		13.10			0.0095	0.0264	15.70		
	0.060	11.20	85.3	0.32	95.1	0.75	5.20	0.0134	4.900		15.50			0.0080	0.0249	18.60		
No. 10..	0.030	5.59	334.0	0.36	401.5	1.46	2.55	0.0275	2.400	9.4	4.65	0.0355	0.0079	0.0173	0.0607	5.58	2.51×10^{-7}	3.7×10^{-3}
	0.040	7.35	185.0	0.34	252.5	1.44	3.20	0.0218	3.020		6.28			0.0136	0.0570	7.55		
	0.050	9.30	123.0	0.33	190.5	1.43	3.67	0.0191	3.460		7.18			0.0119	0.0563	8.60		
	0.060	11.20	85.3	0.32	152.8	1.42	4.11	0.0170	3.890		7.75			0.0106	0.0540	9.30		

1 (increase of C_1), at the expense of a longer die-filling time.

The critical dependence of the porosity of die castings produced on direct-air gooseneck (hot-chamber) machines upon the gate thickness, known to the practical die caster from experience, is thus quantitatively explained and the maximum permissible gate thickness (from the viewpoint of porosity) can now be calculated.

In contrast, the porosity of castings produced on hydraulically driven cold-chamber machines and on hydraulically driven plunger-type gooseneck (hot-chamber) machines is very insensitive as to gate thickness. This follows from column 16, Table II. The optimum vent areas for machines Nos. 2, 3, and 4 are practically the same for gate thickness from 0.030 to 0.060 in. For machines Nos. 1 and 1*a*, the optimum vent area for 0.060-in. gate thickness is only less than 10 per cent greater than for 0.030-in. gate thickness.

Air-driven cold-chamber machines (machines Nos. 5, 6, and 7) and air-driven plunger-type gooseneck (hot-chamber) machines are less sensitive in this respect than direct-air gooseneck (hot-chamber) machines, but much more so than hydraulically driven cold- and hot-chamber plunger-type machines. Machine No. 6, for instance, will produce the casting under consideration with the maximum possible vent area of 5×10^{-4} sq ft under optimum venting condition, that is, with the minimum possible porosity, with a gate thickness of 0.032 in. (Fig. 9).

For the aluminum casting under consideration, the actual die-filling times $(t_3 - t_2)$ for optimum venting condition, shown in column 14, Table II, and in Fig. 9, are the shortest obtainable on the respective machines with gate thicknesses between 0.030 and 0.060 in.

Among the hydraulically driven cold-chamber machines specified in Table III, machine No. 1 is the fastest and machine No. 3, the slowest. With equal

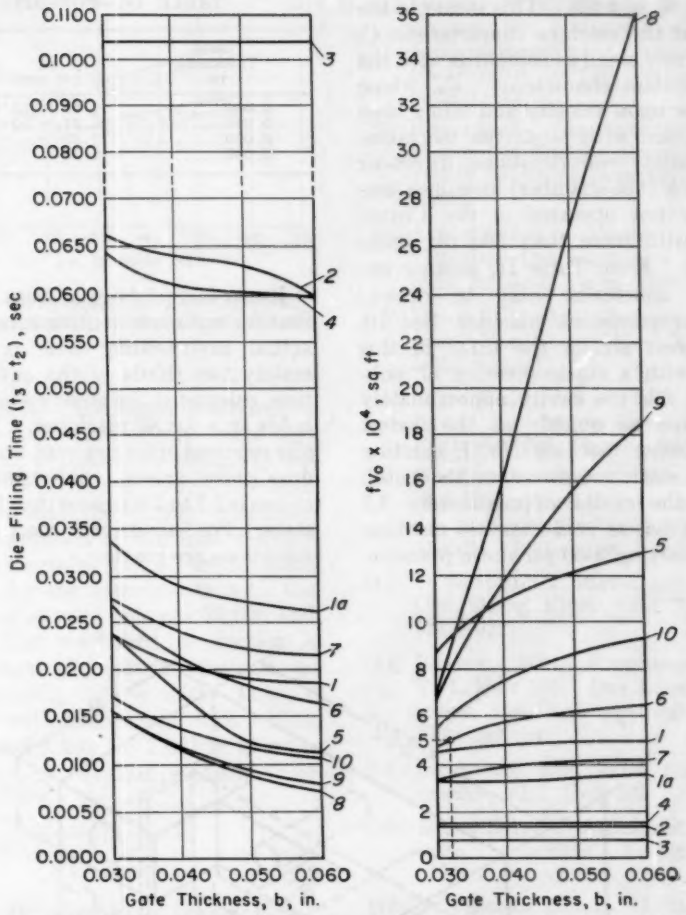

Fig. 9.—Actual Die-Filling Time ($t_3 - t_2$) for Optimum Venting Condition and Optimum Vent Area, f_{v0}, as Function of Gate Thickness, b.

gate thicknesses, machine No. 1 fills the die cavity 4.5 to 5.5 times as quickly as machine No. 3, although the static pressure on the metal, $f_k P_0/f_0$ is only 28 per cent greater for machine No. 1 than for machine No. 3. The reason for this behavior is to be found in the influence of the machine characteristics C_1 and A_1 upon the metal velocity and filling time as expressed by the equations in Table I, which should be taken into consideration in the design of die-casting machines.

Machine No. 1*a*, exerting the same static pressure upon the metal as machine No. 2 and being identical with machine No. 2, with the exception of the pipe-line diameters, fills the die cavity 2 to 2.3 times as fast as machine No. 2.

The influence of the machine characteristics C_1 and A_1 upon filling time is much less pronounced with air-operated cold-chamber machines (Nos. 5, 6, and 7), with air-operated plunger-type gooseneck (hot-chamber) machines, and also with direct-air gooseneck machines

TABLE III.—SPECIFICATIONS AND CHARACTERISTICS OF DIE-CASTING MACHINES.

Machine	Driving Agent	Starting Pressure in Accum. or Tank, psi	Length of Pipe Line		Diameter				Weight of Piston, Piston Rod, and Plunger, lb	Static Pressure on Metal, $\frac{f_k P_0}{f_0}$, psi	ζ	ζ'	C_1, $\frac{\text{lb-sec}^2}{\text{sq ft}}$	A_1, $\frac{\text{lb-sec}^2}{\text{ft}}$
			Drive, ft	Return, ft	Pipe Lines, in.	Piston, in.	Piston Rod, in.	Cold or Hot Chamber, in.						
Cold-Chamber Machines														
No. 1...	hyd oil	2000	13	13	2	4	2¾	2	85	8000	52	48	83.2	13.8
No. 1*a*..	hyd oil	1000	13	13	2	4	2¾	2	85	4000	52	48	83.2	13.8
No. 2...	hyd oil	1000	13	13	1¼	4	2¾	2	85	4000	53.5	49.5	581.0	31.6
No. 3...	hyd oil	1000	13	13	1¼	5	2¾	2	100	6250	53.5	49.5	2580.0	86.1
No. 4...	hyd oil	1000	13	13	2	6	2¾	2	120	9000	52.2	48.2	1260.0	75.5
No. 5...	air	1000	13	13	2	4	2¾	2	85	4000	52	48	2.87	3.02
No. 6...	air	1000	13	13	1¼	4	2¾	2	85	4000	53.5	49.5	20.10	3.64
No. 7...	air	1000	13	13	1¼	5	2¾	2	100	6250	53.5	49.5	89.00	6.00
Direct-Air Gooseneck (Hot-Chamber) Machines														
No. 8...	air	500	13	...	2	...	...	4	...	500	52	...	1.40	0.17
No. 9...	air	500	13	...	1¼	...	...	4	...	500	53.5	...	9.80	0.43
No. 10...	air	500	13	...	¾	...	...	4	...	500	58.0	...	67.5	1.10

(Nos. 8, 9, and 10). This is due to the fact that the machine characteristic C_1 is relatively small as compared with the metal system characteristic C_0, whose influence upon velocity and filling time is dominant with air-driven machines.

For safety considerations, direct-air gooseneck (hot-chamber) machines usually are not operated in the United States with more than 500 psi static pressure. From Table II, another important conclusion may be drawn: direct-air gooseneck machine No. 10, the slowest among the three in this group, with a static pressure of only 500 psi, fills the cavity approximately 1.35 times as quickly as the fastest cold-chamber machine No. 1, exerting 8000 psi static pressure upon the metal. It fills the cavity approximately 3.7 times as fast as cold-chamber machine No. 4, exerting 9000 psi static pressure.

TABLE IV.—POROSITY AND GATE THICKNESS (MACHINE NO. 10).

Gate Thickness, in.	m, per cent	Diameter of Single Blowhole, in.	Diameter of Blowholes, in.		
			10	20	50
0.030.....	1.05×10^{-1}	0.060	0.028	0.022	0.016
0.040.....	5.21×10^{-1}	0.475	0.220	0.175	0.130
0.050.....	1.23	0.630	0.294	0.235	0.172
0.060.....	1.70	0.70	0.325	0.260	0.190

It can further be seen from Table II, that for optimum venting condition the actual cavity-filling time is approximately two thirds of the cavity-filling time calculated for steady state. This holds true for all machines. The actually required optimum vent area for hydraulically driven cold-chamber machines is 2.7 to 3.8 greater than for steady state. For air-driven machines, the variations are greater.

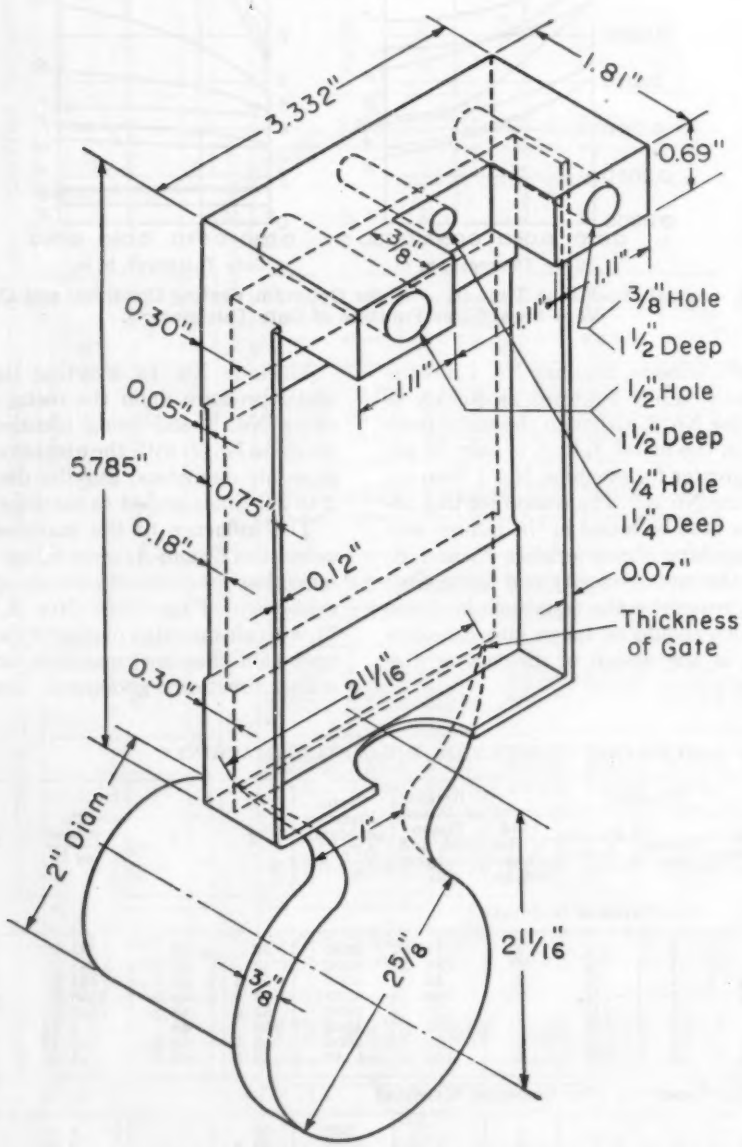

Fig. 10.—Committee B-6 Test Casting and Attached Gate and Residue (3).

Thermal Aspects and Recommendations:

The all-important question: In what time must the die cavity filling be completed in order to result in a satisfactory casting? includes essentially the problem of solidification of the metal in the die and the temperature distribution in the die as function of the time of the shot cycle. The metal entering the cavity in the shape determined by the gate touches the wall of the mold, or core, forming there a layer of approximately one half of the gate thickness. If stratification is to be avoided, the layer must not be allowed to freeze completely before more metal has been deposited. During the process of filling, the metal in contact with the wall can lose heat only to the surface of the wall because of the additional liquid metal coming from the gate. This liquid metal has at least as high a tem perature as that of the layer on the wall From this conception follows the requirement for the filling time: it must not be longer than the time required for a layer of one half of the gate thickness to freeze.

Thus the problems arise of determining the solidification time of the various die-casting alloys as a function of layer thickness (practical range is between 0.008 and 0.050 in.) and of determining die temperature, without any die coating and with a coating of, say, 0.0005-in. thickness.

Temperature measurements by means of the placement of thermocouples would be subject to major difficulties. For example, temperatures could most conveniently be measured only in the die, away from the free surface of the metal layer. However, even if couples were placed in the metal layer, their thermal inertia would make measured results of questionable value. Other means of measuring this thermal pattern might be required.

Computation by classical mathematical means is not practical. However, a different mathematical approach, namely, by means of an analog computer, would be very desirable. Basically, an analog computer is an apparatus which permits the solution of a problem in one field of science, for example, heat, by carrying out measurements in a different field, for example, electricity.

Analog computers have been used successfully for thermal studies and also, particularly, for studies of solidification (17,18,19). The electric analogy method should prove practical for arriving at reliable filling-time data.

Using such data, the present analysis should be of substantial assistance to the die-casting machine-design engineer, the die-design engineer, and the production engineer in coordinating their efforts toward further advances in die-casting technique.

Analysis of Published Experimental Data and Partial Verification of Analytical Approach

Koester and Goehring (7) measured the steady-state velocity of a free jet which emerges from the machine nozzle unhindered into the atmosphere. The casting machine was a small plunger-type (hot-chamber) machine. Built originally for hand operation, it was converted to operate by means of a weight. A weight pan was attached to the lever arm actuating the plunger, permitting a variation of the pressure from 20 to 60 kg per sq cm. Woods metal (50 per cent bismuth, 25 per cent lead, 12.5 per cent tin, 12.5 per cent cadmium) was used as the casting material.

Figure 11 shows the results as reported by Koester and Goehring. Two points at 30 and 60 kg per sq cm are connected by a straight line.[3] For the upper line, the nozzle length was 12 mm; for the lower, 134 mm. The diameter in both cases was 2 mm. All of the results were obtained with a metal bath temperature of 90 C.

The discharge velocity w can be expressed as:

$$w = \sqrt{\frac{2g}{\gamma}\,\frac{p_0}{(1+\zeta)}}$$

where ζ = sum of resistance coefficients of all resistances in the metal system, referred to the velocity w. With a value of $\zeta = 2.14$, line No. 1 in Fig. 11 satisfies this equation within 2 per cent accuracy.

The velocity differences between lines Nos. 1 and 2 are the result of the energy

[3] It would seem that measurements were made only at these points.

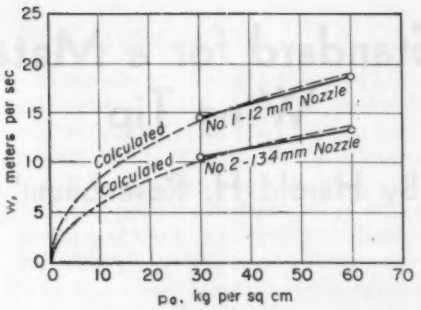

Fig. 11.—Comparison of Experimentally with Analytically Determined Metal Velocities.

losses caused by the longer nozzle length l. These additional energy losses correspond to a resistance coefficient increase $\Delta\zeta = \lambda\,(l/d) + 0.07$. The term 0.07 represents the energy consumed for the formation of the final velocity profile in the tube (16). The Reynolds numbers for the experiments with the 134-mm tube were between 20,000 and 25,000. The coefficient of friction λ follows from the Blasius formula as 0.029, making $\Delta\zeta = 2.02$. Thus, ζ for this experiment was 4.16. With this value of ζ, line No. 2 in Fig. 11 satisfies the above equation within 4.5 per cent accuracy.

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A Procurement Standard for a Metal-Sandwich Type Wing Tip

By Harold H. Rosenbaum[1]

EDITOR'S NOTE.—The author of this paper describes a set of standards. They were developed and initiated by one aircraft manufacturer in an attempt to use a metal-sandwich construction for the primary structural part of a wing tip. The tip will be part of one of its new planes, still "on the boards." The standards represent but one approach and we feel safe in predicting that they will be discussed, criticized, be amended, be praised, be criticized, be amended and criticized again—but *they are being used.* His paper describes a set of standards; but it does more than that. It graphically illustrates the whole "story" of many acceptance standards. In it, there is first shown the need for a tool—specification of the exact, characteristic dimensions or properties required for acceptance—to insure materialization of a plan. The plan includes the use of a "new" engineering material in a difficult, still untried or unproved application. It is envisioned that successful application would result in a fundamental, forward step in the evolution of some other over-all plan for progress. But it is seen that to measure these specific characteristics standard tests are also required. There follows a period of development for tests, for specifications, and sometimes, for the material concerned, this material's development being a direct result of the standard development. So the story continues; there are advances and reverses—more of the former, usually, until the tool is finished. With it, the little plan materializes and the over-all plan goes forward. Mr. Rosenbaum's paper describes such a story.

A New Standard—Child of Progressive Design:

CONSOLIDATED Vultee Aircraft Corp. (Convair) is building a high-performance, interceptor airplane. In its wing, the ratio of wing thickness to chord length is low—approximately 5 per cent. In fact, in the wing tip (6-ft chord, 3-ft span, 3-in. root-thickness) the thickness decreases to the point that other than conventional design-construction methods have been studied for possible use.

These had to produce with consistent high quality such a wing tip having light weight, adequate strength, and stiffness. Since these tips will function sometimes at elevated temperatures which are due to aerodynamic heating, they also had to be satisfactory from this viewpoint.

Based on the results of earlier experiments with honeycomb sandwich construction, it was felt that these design demands could be met if adequate standards for the components, the sandwich, and the tip assembly were drawn up and if fabrication and testing were in accordance with these standards. It was decided to use the honeycomb sandwich.

At Convair, this represented what would be the first application of sandwich construction to a primary structural part. Therefore it also was decided to develop the necessary standard methods and specifications, working closely with fabricators since Convair did not make its own sandwich materials. In drawing up these standards, the experience gained during earlier work on sandwich constructions was digested and written into these specifications.

Comes from Earlier Experience:

Convair's engineers, in the belief that the high-strength, lightweight sandwiches might provide the answer to a flooring application in a newly designed "Convair-Liner," commercial airplane, had tried to use a sandwich construction.

It consisted of a $\frac{3}{8}$-in. hexagonal, 8-oz cotton duck honeycomb core with aluminum skins bonded to the core with a modified phenolic adhesive.

This early application was characterized, at first, by many failures—frequent replacement was necessary. Indirectly these failures were due to the heavy traffic which occurs in a modern commercial airplane. Usually, the direct cause was attributed to a failure of the skin-to-core bond, the failure being induced by repeated loadings. A change was made to a sandwich having an aluminum honeycomb core (4.2 lb per cu ft, density) with a $\frac{3}{8}$-in., hexagonal size, and a 0.003-in. foil thickness. The adhesive was again of the modified phenolic type. Although it was rather brittle and notch-sensitive, it was considered structurally satisfactory. Some improvement in service life resulted.

But soon after this change, the rejections of these panels in the assembly shop increased to an alarming rate. They were caused by bond failures initiated usually at a corner (due to transportation damages, dropping, or by trimming operations) and rapidly propagating until the panel was unusable.

To solve the bond problem, Convair and a local adhesive and sandwich panel manufacturer working together developed a supported-film adhesive. The film was phenolic resin modified with elastomers; the carrier for support of the film was a glass skrim cloth. Soon it was evident that panels made using this tape adhesive possessed two important advantages: (1) the force required to peel the skins from the core was greatly increased, and (2) failure in a broken skin-to-core bond was not propagated so rapidly as in the former panels.

There had been no positive method of establishing the reliability and integrity of the core-to-skin bond. (This fact was and still is probably the greatest single deterrent to the use of sandwich components.) So, in order to measure the force required to pull the skins from the core of the new panels, a rotating-drum peel test was devised which measures inch-pound of torque required to peel the skins from a 3-in. wide panel. A value of 40 in.-lb was obtained consistently when the total adhesive weight was 0.130 lb on a sandwich 1 ft square. Numerous tests have since indicated that skin differences from 0.012 to 0.020 in. have relatively small effect on the peel strength of the sandwich. But although there is an increase in peel strength as the honeycomb cell size is decreased, the data accumulated show too great a scatter to establish definite values for core sizes.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

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It was found that during the development of the peel test a layer of skrim cloth or cheesecloth between the skin and core of the sandwich raised the strength of the so-called low peel adhesive to a value above the minimum requirement. This was significant in that it enabled manufacturers skilled in the use of brittle adhesives to produce higher bond strengths in their panels with a minimum of change in their process techniques.

Numerous impact fatigue tests were run in this early period to determine the service life of the new panels. The tests consisted of dropping a 50-lb weight $1\frac{1}{4}$ in. onto the center of a 12 by 20-in. honeycomb sandwich panel set on supports 18 in. apart. The load was raised and dropped 60 times per minute.

The results of these early tests showed the high-peel-bond panels withstood from 3 to 10 times the number of impact cycles withstood by the low-peel-bond panels.

Service life reports and shop rejection rates have been much more favorable since the higher peel-bond panel and these early tests to measure peel strengths were developed. This period restored confidence in sandwich construction at Convair. Also, valuable experience had been gained which was to be used later in the design and fabrication of the wing tip for the interceptor plane.

Covers Important Manufacturing Phases:

First, a preliminary drawing which specified the over-all dimensions required and the type of sandwich desired was prepared and sent to the fabricator.

Next, a detailed specification was written covering design, construction, and testing requirements. In it were specified the materials, maximum weight, operating conditions, and the limit loads.

It was written so that the fabricator was to qualify for acceptance the sandwich components, the panel, and finally the wing-tip assembly. This was to be done by qualification tests on samples of products submitted as satisfactory products.

Similar samples were to be tested from each day's production to insure continuing quality control in the manufacturing process.

Final inspection tests were to be performed by the fabricator on finished wing tips submitted as satisfactory for acceptance. These tests were to determine general conformance with the requirements of the specification.

Uses Qualification Tests:

Components.—Perhaps the most critical material making up the sandwich will be the adhesive used for the core-to-skin bond. Ordinarily an adhesive would be specified which, from past experience, proved satisfactory and which would conform to Air Force Specification No. 14164.

In this case, however, temperatures well above 200 F will be encountered so that the adhesive will have to exceed the ordinary requirements and will have to be qualified at the higher temperature. Also, in the high-temperature shear test described under paragraph 4.3.3.1, the minimum strength shall be 1625 psi instead of 1250 psi. In the high-temperature, long-time shear test, the minimum strength shall be 800 psi.

From some preliminary tests it appears that perhaps two adhesives will meet the above requirements. There are indications from other sources that two other adhesives may be able to qualify.

The honeycomb type of core to be used shall conform to Specification MIL-C-7438 and have a 4 to 5 lb per cu ft density. Most likely, a perforated or permeated core with a cell size no larger than $\frac{1}{4}$ in. will be used.

The skin of the sandwich will probably be 0.032 in. thick and will be of 24ST 86 (24SRT aged) aluminum alloy.

Sandwiches.—Upon qualification of the components, they shall be assembled into sandwich specimens. The sandwich specimens shall be made in exactly the same manner using the same core, adhesive, and skin thickness as will be used in the production unit. The specimens shall have a 2-in. thick core and shall be 3 in. wide and 30 in. long. These dimensions were selected so that when the specimen is tested simultaneously for core shear and bending, the center portion, in pure bending, will be long enough to avoid interference from the loading points. The specimens will be loaded in a manner described in Convair Specification ZM-393C, Specification for Sandwich Construction. Essentially, the sandwich is supported 1 in. in from either end, and the load is applied at two points calculated to stress the core in shear at 80 per cent of the value listed in Specification MIL-C-7348. The distance between the end supports and the load application points is referred to as the "A" distance in the Convair specification and is calculated by the formula that follows:

$$A = \frac{F_c t'}{F_s}$$

where:

F_c = compression stress of skins (40,000 psi for 24ST alloy),
t' = thickness of skin in test, and
F_s = 80 per cent of shear strength of core as listed in applicable specification.

The load applied to the specimen is determined by the formula:

$$L = 6F_s h$$

where:

F_s = 80 per cent of the core shear strength and
h = distance between the centroid of the skins.

Two specimens shall be tested at room temperature as described above, and the load at failure shall be at least 10 per cent above the calculated load. The additional 10 per cent is required because it is felt that extra care will no doubt be taken to make the specimens so that better-than-production parts will result.

Two additional specimens shall be heated to the required temperature for $\frac{1}{2}$ hr and tested at that temperature and shall withstand a load of at least 65 per cent of the calculated room temperature value plus 10 per cent.

Two specimens shall be heated to the required temperature for 10 hr and tested at temperature; two specimens shall be heated for 100 hr and tested at temperature; and two specimens shall be heated for 300 hr and tested at temperature. The specimens shall all withstand a load of at least 65 per cent of the room temperature load plus 10 per cent.

Two specimens shall be submerged in boiling tap water for 1 hr and then loaded at room temperature. The specimens shall withstand a load equal to the calculated room temperature load. (This test was desighed to check the cleanliness of the skins which are to be cleaned by the sulfuric acid and sodium dichromate process as outlined in the Forest Products Laboratory *Bulletin No. 1813*, Method E(1).)

Peel tests as described in the Convair Specification shall be conducted on the two specimens originally used for the room temperature flexural tests and on the two specimens that were submerged in boiling water. A peel value of at least 50 in.-lb of torque shall be attained.

The Finished Assembly.—After the above sandwich qualification tests are satisfactorily completed, two units shall be manufactured on production tooling for test purposes. The first unit shall be heated to the required temperature and held at this temperature for 30 min. While at this temperature, the unit shall be tested to destruction with the load distribution as specified in the procurement specification. The minimum required load shall be the ultimate design load (1.5 × limit load).

The second unit shall be heated to the required temperature and held at this temperature for 5 min. The limit load shall then be applied and sustained for 1 min after which the load is to be removed and the unit cooled to 125 F or less. This cycle shall be repeated 199 times. Upon completion of 200 cycles, the unit shall be tested at temperature to destruction as described.

Includes Quality Control Tests:

The next five completed units shall be tested to destruction. The minimum requirement shall be the ultimate load times 1.54 at room temperature or the ultimate load at the required temperature after being heated 30 min at this temperature. The 1.54 is a factor determined as the expected loss in strength of the unit at the elevated temperature.

The reason for testing the five units is to check the reproducibility of the production tools and the manufacturing process. Unless a good test value can be obtained time after time, some construction other than sandwich will have to be used for the tip.

Beginning with the sixth production unit, each unit shall be proof-loaded to limit load × 1.54 at room temperature or to limit load at the required temperature after being heated at this temperature for 5 min. Each unit passing the above test shall be regarded as an acceptable unit.

In addition to the above tests, two 3 by 30-in. specimens shall be made with each production lot. These specimens are to be tested in flexure at room temperature as previously described and shall withstand the calculated load and peel requirements. (These tests will serve as a check on the proof-loading test. If a correlation between the two tests can be established, the proof-loading test will not be required for each and every unit. The proof-loading will then be applied only to samples selected in some manner to be determined in the future.)

Cost is Justified for Progress:

Convair realizes that they have taken a very conservative view in working up the procurement specification for this wing tip. They also realize that such conservatism is going to increase the cost of the wing tip. It is felt, however, that such thinking is justified, because the company hopes to prove that a reliable structural sandwich can be made. The final proof will be obtained only after the parts are actually in service and a record of their performance studied.

A Constant Strain Stiffness Tester for Thin Plastic Films

By F. D. Dexter[1]

One of the more important properties of elastomeric films and sheetings is their apparent modulus of elasticity, or "stiffness." Being usually a single point value, this "stiffness" is not unique because of the time, strain (or stress), and temperature-dependent properties which characterize the deformation of nearly all elastomers. It is, however, a useful quantity by means of which materials may be classified generally.

Most elastomers have complex deformation properties which result from creep[2] and relaxation phenomena[3] and nonlinear stress-strain relations.[4] The nature of these characteristics is known, at least in general, for many materials. Although it is difficult to express this behavior in terms of any single, practical figure, or combination of figures, a recognition of the effects is essential to properly assess the more empirical data. Because of these complex deformation characteristics, data for single point stiffness figures to be used in comparisons must be obtained at the same temperature, strain (or stress), and time. Even then caution should be exercised since through a fortuitous combination of complex properties two otherwise different materials might exhibit similar stiffness values. For this reason single point tests are most reliable and useful when materials of generally similar composition are being evaluated.

In designing apparatus for determining the stiffness of thin films and sheetings, some of the primary test requirements are (1) sensitivity, (2) precision, (3) ease of operation, (4) speed of operation. The cost of the equipment is another factor which must be held to a reasonable value. Based on these requirements, an instrument has been built and is described in the following section.

Briefly, this apparatus consists of a mechanism by which a known strain is quickly applied to an annular specimen. The load required to maintain this strain is measured through use of a commercial strain gage bridge.[5] From this load, combined with the specimen thickness and the strain, a modulus can be computed. The sensitivity, which is adjustable, is such that stiffness values for thin films (down to 0.002 in. thick) can easily be measured. Test precision is limited primarily by the precision with which thickness can be measured and by the uniformity of the sample thickness. The test is easy to run; the time requirement is about 2 min per value, including sample preparation and computations.

Description of the Instrument:

The instrument consists of a mechanical device to elongate an annular specimen and a strain gage system to measure the tensile load. The apparatus is shown in Figs. 1 and 2.

The mechanical part includes a movable bar which slides through a guide block and a lever which is connected to a strain gage. The bar has a handle at one end and a hook at the other. The movement of the bar is limited by a permanent stop, but the distance that the bar can be pulled back may be altered by placing Ω-shaped blocks (removable stops) over the bar between the guide block and the permanent stop. This permits the use of a variety of strain levels.

The strain gage system is made up of a lever with adjustable fulcrum, strain gage, voltage source, and suitable meters for measuring input and output current. The commercial strain gage[5] consists essentially of four resistance strain gages

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[1] Development Laboratories, Bakelite Co., a Division of Union Carbide and Carbon Corp., Bound Brook, N. J.

[2] W. Aiken, T. Alfrey, A. Jannsen, and H. Mark, "Creep Behavior of Plasticized VYNW," *Journal Polymer Science*, Vol. 2, p. 178 (1947).

[3] T. Alfrey, M. Weiderhorn, R. Stein, and A. Tobolsky, "Some Studies of Plasticized Polyvinyl Chloride," *Journal Colloid Science*, Vol. 4, p. 211 (1949).

[4] Ladislav Boor, "Some Notes on the Effect of Testing Machines on the Tensile Properties of Plastic Film," ASTM BULLETIN, No. 162, Dec., 1949, p. 47 (TP 215).

[5] Statham gage, Model G1-48-675. Statham Laboratories, Inc., Beverly Hills, Calif.

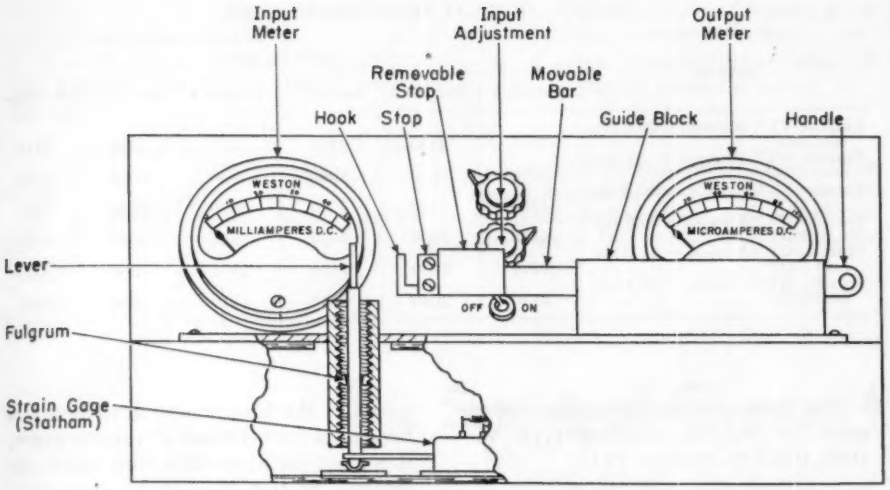

Fig. 1.—Constant Strain Stiffness Tester.

built up in a bridge circuit. Any load on the shaft of the gage causes an unbalance which is indicated on the output meter. The output current is directly proportional to the force on this shaft. Variation in the position of the fulcrum will change the ratio between the force applied at the upper end of the lever by the specimen, and the force at the gage. In this way the sensitivity can be varied.

A necessary preliminary step in the operation of the strain gage system, once the sensitivity has been adjusted to the desired level, is calibration. This is done by a dead loading technique; only two or three points are necessary, since the linearity of the gage is excellent within its load limit (48 oz). From these data a calibration factor (for example, grams per microampere output) is computed. All measurements, as well as the calibration, must be done with the input current constant. A meter and means for adjusting the input current are provided for this purpose.

The output meter used is Weston Model 643 microammeter with a 100-microamp range and an internal resistance of 385 ohms. There are several suitable microammeters available but it is necessary that one be selected whose internal resistance is moderately low (less than 400 to 500 ohms) in order to retain sensitivity. It is also possible to use a recording potentiometer on the output and thus get a continuous record of the load with respect to time.

Input to the gage is supplied from a C battery connected in series with a 1000-ohm potentiometer. The latter is used to adjust the input to the proper level. Either a voltmeter or milliammeter can be used to measure the input. In the present instrument a Weston Model 643 milliammeter with a 0–50-milliamp range is used.

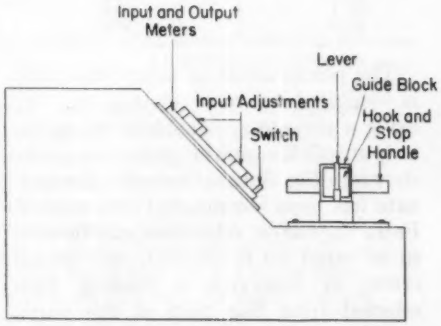

Fig. 2.—Side of Constant Strain Stiffness Tester.

Operation:

This instrument uses an annular specimen which is die cut from calendered or pressed sheet. While practically any dimensions can be used, it is desirable to have the specimen width small compared to the diameters. Specimens $\frac{1}{8}$ in. wide with an outside diameter of 1.403 in. and an inside diameter of 1.153 in. were found to be satisfactory. These dimensions give a central fiber length of 2 in.

Before running the test, specimens should be allowed to reach equilibrium with room temperature or to be fully influenced by other conditioning which has been determined to allow valid comparison of results among the specimens. Also, because the modulus depends on strain[4], comparisons should be made at the same elongation. Using an extra test specimen the proper elongation can be determined prior to actual testing, by the same test procedure.

After adjusting the strain gage input current to the proper value, the annular specimen is placed over the hook and the lever; the bar is quickly pulled back against the stop (see appendix); and after a given period of time the output meter is read. (When the specimen is elongated it must lie flat.)

Due to relaxation effects (see discussion) the reading on the output meter will decrease with time. It is thus necessary to select a somewhat arbitrary time at which the meter is to be read. A time of around 10 sec has been found suitable. Selecting 10 sec or longer allows an error of 1 sec to be tolerated easily.

Having determined the specimen dimensions and the output meter reading, a modulus can be computed from the equation

$$E = \frac{M \times F(1+\epsilon)}{2A_0 \times \epsilon} \quad \ldots\ldots(1)$$

where:

E = apparent tensile modulus (stiffness),
M = output meter reading,
F = gage system calibration factor,
A_0 = original cross-sectional area of the specimen, and
ϵ = tensile strain.

The factor $(1 + \epsilon)$ corrects for the change in cross-sectional area with strain. An equation for the strain is developed in the appendix; this is

$$\epsilon = \frac{2L + 2R(\pi - 2) + \pi t - C}{C} \quad \ldots(2)$$

where:

L = distance between hook and lever with stop against guide block,
R = radius of the hook and lever (these are equal),
t = sample thickness, and
C = original length of central fiber.

The above equation is applicable only if some tensile strain is imposed across the whole sample. It is evident that since the original specimen was annular a certain over-all minimum elongation must exist before the outermost fibers in the sample are strained. If the outer circumference is C'' then, for strain to exist on the whole sample,

$$2L + 2R(\pi - 2) + \pi t \geqq C'' \ldots(3)$$

For specimens having the previously given dimensions, the minimum allowable strain (Eq 2) is about 11 per cent.

If only comparisons are to be made or if this instrument is used in a control test, the value of reducing the meter readings to equivalent moduli is questionable. In this connection it should be noted that the effect of thickness is primarily to change the area; very little change in strain results (Eq 2). Thus, meter readings on samples of slightly different thickness can be corrected, on the basis of inverse proportion, to some mean thickness level.

Discussion of Measurements:

The speed, and to some extent the precision, of this test was achieved

through limiting the determination to a single point with respect to strain and time. The computed modulus is dependent on both of these[3,4]. Thus, it is necessary to make comparisons at the same values of strain and time. Small changes in temperature are of little importance in many stiffness tests. But it is also well known that the temperature can have a large effect on the stiffness of elastomers. Temperature does affect the results obtained with this instrument. Even the usual, allowable fluctuation in a constant temperature room results in significant changes in the modulus determined. Because of this, unfortunately, a series of determinations must be run within a relatively short period of time if only very small differences are to be detected.

The effect of strain on stiffness of many elastomers is such that the apparent value is lower as the strain level is increased. Note, for example, the following data obtained using this instrument on Vinylite sheeting type VU-1900, 0.012 in. thick at 27 C:

Strain, per cent	Apparent Modulus, psi
23.7	1288
48.5	1054
68.1	943
92.9	836

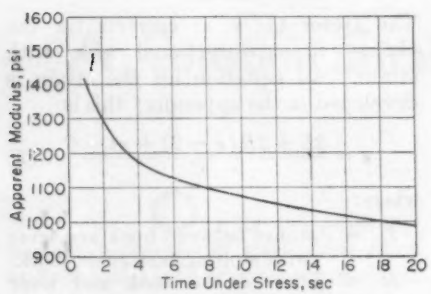

Fig. 3.—Change in Apparent Modulus with Time Under Stress.

The phenomenon of stress relaxation is exhibited by most elastomers. By using a recording potentiometer on the output of the strain gage the curve shown in Fig. 3 was obtained; the ordinate has been recomputed into moduli. From the curve, relaxation can be seen to be rapid up to about 6 sec. Small errors in observing a reading time selected from this part of the curve would create large errors in the apparent modulus. But beyond 6 sec relaxation becomes relatively slow. The test reading time was selected from this latter portion of the characteristic.

TABLE I.—TYPICAL STIFFNESS RESULTS.

Material	Stiffness, psi					
	Sample 1	Sample 2	Sample 3	Sample 4	Sample 5	Average
Vinylite VYNW resin + 29.6 per cent DOP	2320	2430	2460	2420	2420	2410
Vinylite VYNW resin + 31 per cent DOP	2070	2050	2080	1960	2080	2050
Vinylite VYNW resin + 32.4 per cent DOP	1700	1640	1700	1670	1640	1670
Vinylite QYNA resin + 29.6 per cent DOP	2530	2600	2660	2660	2630	2610
Vinylite QYNA resin + 31.0 per cent DOP	2220	2240	2150	2250	2260	2220
Vinylite QYNA resin + 32.4 per cent DOP	2130	2090	2060	2110	2090	2100

While the instrument described has been used for materials of various gages, it is most useful for thin films which are difficult to test quickly by any other method. Some examples showing the general nature of its performance on calendered film of 0.004-in. nominal thickness are shown in Table I. All tests were run at 23 C using a strain of 25 per cent. These data show the precision of the test to be about ±2 per cent at the 95 per cent level.[6] It should be noted that variability in the thickness measurement and variation of thickness within any one specimen are probably greater than the actual test error. These, then, limit the precision of the stiffness value.

The ability of the test to detect small differences in plasticizer content and resin type is also evident.

[6] Based on the average of five tests. Precision is ±4.06 per cent on a single value at the 95 per cent level.

APPENDIX

Development of Equation for Strain in Annular Specimens

Originally the specimen is an annulus cut from the film or sheet. In the elongated position it assumes the shape of a flattened cylindrical surface, the inner diameter stretching to become equal to the outer diameter, as shown in Fig. 4. The old width of the specimen becomes the height of the cylindrical surface. Essentially, two rectangular strips result, stretching between the hook and lever of the machine. It is thus obvious that the fibers nearest the original inner side are strained the most and that the strain decreases as the original outer side is approached. A linear strain distribution is shown in Fig. 4 where the original inner edge is at the bottom. When such a strain distribution is assumed, then the average elongation can be taken as that at the central fiber (mid-point in the specimen with respect to both width and thickness).

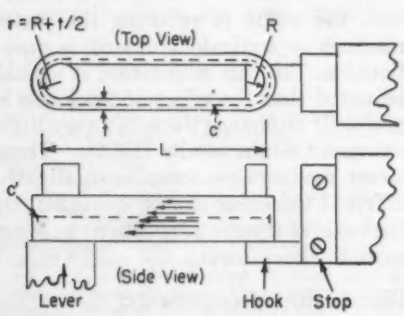

Fig. 4.—Elongated Specimen Showing Linear Strain Distribution.

Under these conditions the strain ϵ is

$$\epsilon = \frac{C' - C}{C} \quad \ldots\ldots (1a)$$

where:

C' = elongated length of central fiber, and
C = original length of central fiber.

If L is taken as the distance between the hooks as shown in Fig. 4, then C' will be related to L by

$$C' = 2(L - 2R) + 2\pi r \ldots . (2a)$$

where:

R = cross-section radius of hook and lever, and
r = mean radius of sample around hook and lever.

Because of the sample thickness, t, its mean radius is slightly greater than that of the hook. Thus, the value for r is

$$r = R + t/2 \ldots\ldots\ldots (3a)$$

Substituting Eqs 2a and 3a in 1a the complete equation for the strain is

$$\epsilon = \frac{2L + 2R(\pi - 2) + \pi t - C}{C} \ldots (4a)$$

The above equation is applicable only when some strain exists across the complete sample. That is, the strain must be sufficient to just elongate the original outer fibers. This condition is fulfilled when

$$2L + 2R(\pi - 2) + \pi t \geqq C''$$

where:

C'' = original outer circumference.

If a specimen of dimensions given pre-

viously is used, the minimum strain turns out to be about 11 per cent.

Once the strain has been determined, the apparent modulus, E, can be calculated from

$$E = \frac{M \times F}{2A \times \epsilon} \quad \ldots\ldots\ldots (5a)$$

where:

M = reading from output meter, microamps,

F = calibration factor for gage, g (or lb) per microamp, and

A = actual cross-sectional area of sample, sq cm (or sq in.).

The factor 2 is used since the sample is looped around the hooks and the tension is exerted on two strips, each of area A. The area is that which exists when the sample is elongated and is related to the original area, A_0, by

$$A = \frac{A_0}{1 + \epsilon} \quad \ldots\ldots\ldots (6a)$$

The final equation for the modulus is

$$E = \frac{M \times F \times (1 + \epsilon)}{2A_0 \times \epsilon} \quad \ldots\ldots (7a)$$

The Setting of Gypsum Plaster

By H. C. Fischer[1]

SYNOPSIS

Some of the salient points in the historical background concerning the colloidal and crystallization theories of the setting and hardening of gypsum plaster are set forth.

Experimental evidence derived from this investigation corroborates the work of those in the past who pointed to a colloidal mechanism involved in the initial set rather than the formation and intergrowth of a crystalline hydration product. The latter mechanism is the principal cause of final set or hardness of the system.

Differential thermal analysis of gauged plaster of Paris in contact with its mixing water for various periods of time shows that the hydration of the hemihydrate to the dihydrate occurs after the initial set has taken place. Prior to chemical hydration, water is held in an adsorbed condition and has not entered into chemical combination with the hemihydrate.

THE mechanism involved in the setting and hardening of gypsum plaster and cements has been a controversial subject for over a hundred years. Although the primary purpose of this paper is to discuss the setting of gypsum plaster and to present some experimental work thereon, the historical background necessary to such a discussion is concerned with both plaster and hydraulic cements since these materials when in contact with water react in a somewhat similar manner even though the cement-water system is of much greater complexity.

There have been and to some extent still are two schools of thought, one favoring the crystallization theory, the other favoring the colloidal theory.

HISTORICAL BACKGROUND

The Crystallization Theory:

The crystallization theory was first propounded, although indirectly, by Lavoisier (1)[2] in 1765 when he published the following explanation of the setting of gypsum plaster:

If gypsum which has been deprived of its water by heating, is again treated with water, it takes up the latter with avidity, a rapid and irregular crystallization occurs and the small crystals which are formed are so entangled with each other that a very hard mass results.

Le Chatelier (2), however, may rightfully be called the champion of the crystallization theory. From experimental studies he concluded that the crystallization of plaster and also cements occurs from supersaturated solutions, metastable conditions caused by solubility differences between hydrated compounds, and anhydrous or partially hydrated compounds.

The Colloidal Theory:

The colloidal theory with respect to the setting of plaster and other cementitious materials is generally credited to the investigator Michaelis (3). Although his ideas were fundamentally sound, his viewpoint unfortunately was quite narrow and consequently he found it difficult to accept any ideas other than those leading exclusively to the formation of colloidal hydration products.

As vigorously as did Michaelis maintain his theory, so Le Chatelier defended his own. In 1919 Le Chatelier sent in a contribution to the General Discussion of The Setting of Cements and Plasters, entitled "Crystalloids Against Colloids in the Theory of Cements" (4) in which he stated:

I have always opposed the theory which attributes the hardening of cements to certain colloidal properties of the material, as being devoid of sense. . . . People evade defining what they call a colloid but they seem to take the word in the sense of a body capable of hardening. And then the explanation comes down to this: cements harden because they have the property of hardening. . . . These very minute bodies possess one quite special and very important property of absorbing (by snobbery one prefers to speak of adsorbing nowadays) the soluble bodies which are held in solution by the liquid with which they are wetted.

Traube (5) in 1919 published the results of his experimental work on the setting of plaster. He concluded that a gel structure is first formed which gradually changes to crystalline gypsum and that the acceleration and retardation of the set by salts, acids, organics, etc., follows the same sequences as for the flocculation and dispersion of other colloidal processes.

In 1926, Le Chatelier presented to the French Academy of Sciences a paper written by Baykoff (6) in which, surprisingly enough, the gel or colloidal theory appeared to take an important step forward.

Perhaps the best discussion of the theories and a means of reconciliation has been made by Desch (7) although his phraseology is unnecessarily censorious, as can be seen in the following quotation:

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[1] Assistant Professor of Materials, Building Materials Research Laboratory, Department of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

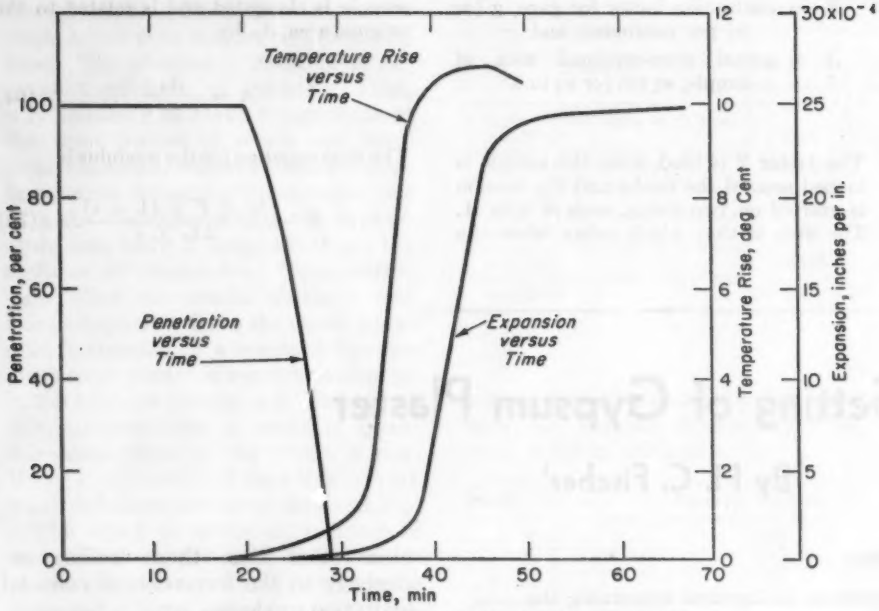


Fig. 1.—Plaster of Paris (200 g) Plus Distilled Water (100 ml).

The real nature of the colloidal condition has been unnecessarily obscured by the barbarous terminology which has been adopted by so many writers on the chemistry of colloids, and especially by the school of Wo. Ostwald. Stripped of these uncouth technical terms, the study of colloids appears far less formidable, and it is to be hoped that the present discussion may, by putting in relief the views of the supporters of the two rival hypotheses as to the setting and hardening of cement, lead to a recognition of the true facts of the case, and to an elimination from the subject of the complications which owe their origin largely to a defective terminology.

He pointed out that the differences between the theories of Michaelis and Le Chatelier were primarily due to differences in experimental conditions, namely, one worked with dilute and the other with concentrated solutions.

Both theories have been supported by numerous competent investigators. It appears that both theories are correct to a certain extent but, nevertheless, a combination of both is essential and can be reached if the minor differences, primarily of definitions, are dispelled by clarification.

As a result of his own experimental work on plaster and a study of the work of others, Neville (8) pointed out that:

1. The set is retarded with increasing proportions of water in the mix.
2. Although the formation of gypsum crystals is accompanied by an expansion, the final volume is less than the sum of the original volumes of the materials by about 7 per cent.
3. Cations are important factors in accelerating the set and their activity or effect agrees with the order in which they precipitate colloids from solution.
4. Retarders prevent gel formation.
5. Prolonged stirring shortens the time of setting.
6. Ostwald and Wolski, by measurement of viscosity of dilute suspensions of plaster of Paris, believe that their results indicate the colloidal nature of the system by analogy to properties of known colloids.
7. Ordinary plaster of Paris made by the dehydration of gypsum must have a very incomplete crystal structure with residual crystal forces and an enormous surface, and it is to be expected that this type of material would have very strong adsorptive forces.

Neville also took serious issue with previous investigators who claimed that any substance which increases the solubility of calcium sulfate will accelerate the set and that substances which decrease the solubility must retard the set. He showed these claims to be unwarranted by studying the effect of increasing concentrations of ammonium sulfate on the set of plaster. Although the rate of set increased with increasing concentrations of the salt, the solubility of the calcium sulfate first decreased quite rapidly, went through a rather sharp minimum, and then proceeded to increase linearly. He also pointed out that practically all soluble sulfates decrease the solubility of calcium sulfate, yet these markedly accelerate the set.

Experimental Work

As was pointed out at the beginning of this paper, the purpose of this work was to study the mechanism involved in the initial setting of gypsum plaster. The final set or hardening is undoubtedly due to the progressive growth and intergrowth of gypsum crystals.

When uncontaminated plaster of Paris ($CaSO_4 \cdot \frac{1}{2}H_2O$) is gauged with water, the following characteristics may be observed:

1. A setting or initial stiffening of the paste occurs about 20 min after mixing (for mix proportions used in this investigation). During the time preceding this stiffening, very little temperature rise, if any, occurs.
2. Shortly after the initial set has taken place, a pronounced temperature rise and a measurable expansion are noted which reach a maximum 20 to 30 min later. (See Fig. 1.)

In view of these experimental facts it appears that the chemical hydration of the hemihydrate occurs at a considerable length of time after gauging with water. That this is true will be shown in a later section of this paper.

Effect of Admixes on Setting Time:

In order to investigate further the possibility of a gel or colloidal structure, the effect of various substances on the setting time was studied. In all cases the plaster mix consisted of 200 g of plaster of Paris and 100 ml of distilled water (20 C) or 100 ml of the mixing liquid (admix in distilled water). This particular mix was chosen because of its consistency.

The plaster was added to the liquid (in a rubber mixing bowl) and mixed thoroughly for exactly 1 min. The resulting smooth, lump-free paste was then poured into a lubricated, nonabsorptive, hard-rubber mold,[3] and leveled off with a spatula. Penetration tests were made at regular intervals by means of a Vicat needle.[3] In some cases a greased thermometer was inserted in the mold to observe the temperature effect.

The following admixes, in distilled water, were used to determine their effect on the time of initial set:

Aluminum sulfate, $Al_2(SO_4)_3 \cdot 18H_2O$	0.2 per cent solution (by weight)
Magnesium sulfate, $MgSO_4 \cdot 7H_2O$	0.2 per cent solution (by weight)
Potassium chloride, KCl	0.2 per cent solution (by weight)
Potassium sulfate, K_2SO_4	0.2 per cent solution (by weight)
Daxad No. 21[a] (a commercial dispersing agent)	0.2 per cent solution (by weight)
Victawet No. 12[b] (a commercial dispersing agent)	0.2 per cent solution (by weight)
Alcohol (95 per cent C_2H_5OH + 5 per cent CH_3OH)	10 per cent solution (by volume)
Alcohol (95 per cent C_2H_5OH + 5 per cent CH_3OH)	50 per cent solution (by volume)
Gelatin powder	0.2 per cent solution (by weight)

[3] Methods of Testing Gypsum and Gypsum Products (C 26 - 52), 1952 Book of ASTM Standards, Part 3, p. 272.

[a] Dewey & Almy Chemical Co. [b] Victor Chemical Works.

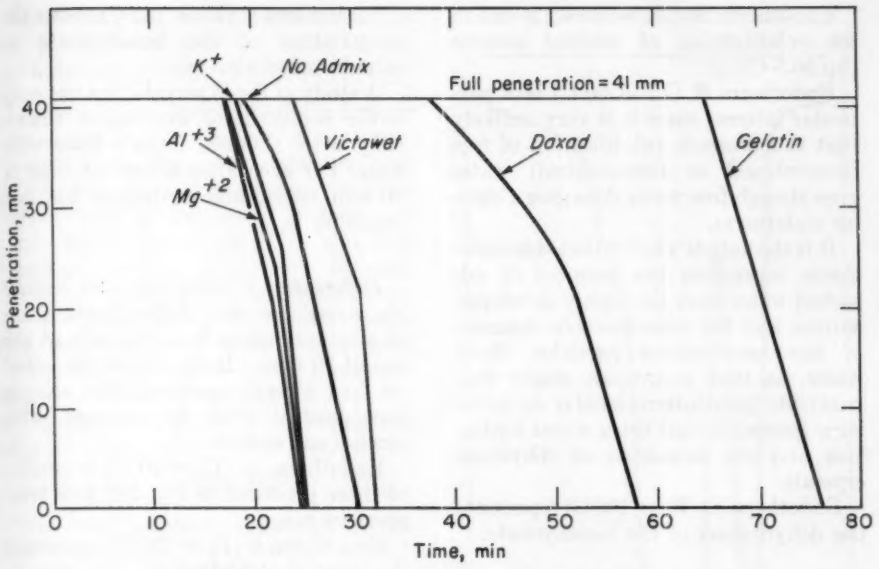


Fig. 2.—Effect of Admixes on Setting Time.

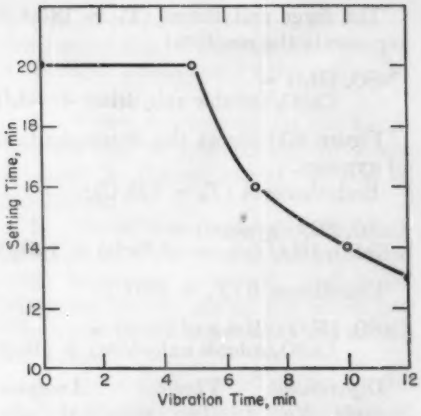


Fig. 3.—Effect of Mechanical Vibration on Setting Time.

The initial set of a batch of plaster was arbitrarily taken to be the time at which full penetration, by the Vicat needle, was prevented by the stiffening of the mix.[3] This setting time was found to be reproducible to a satisfactory degree.[4] Table I shows the effect of the above admixes on the setting time.

TABLE I.—EFFECT OF ADMIXES ON SETTING TIME.

Admix	Time of Initial Set,[a] min
Al^{+3}	17
Mg^{+2}	17
K^{+}	18[b]
No admix	20
Alcohol (10 per cent)	20
Victawet No. 12	24
Daxad No. 21	37
Gelatin	65
Alcohol (50 per cent)	120

[a] Includes initial mixing time of 1 min.
[b] KCl, 18 min; K_2SO_4, 19 min.

Figure 2 is a graphical presentation of these data. The alcohol admixes are not plotted because of the scale limitations.

Effect of Vibration on Setting Time:

The effect of vibration on the standard mix and its relationship to the setting time was determined by placing a lightweight paper cup containing the mix on a rapidly vibrating board. Vibration was accomplished by means of a small electrical vibrator attached to one end of the board. After a fixed period of vibration the set was determined by the Vicat needle penetration test.

Table II shows the effect of vibration on the setting time.

[4] Triplicate tests with agreement between individual tests of 0.25 min.

TABLE II.—EFFECT OF VIBRATION ON SETTING TIME.

Time of Vibration,[a] min	Time of Initial Set,[b] min
0	20
5	20
7	16
10	14
12	13

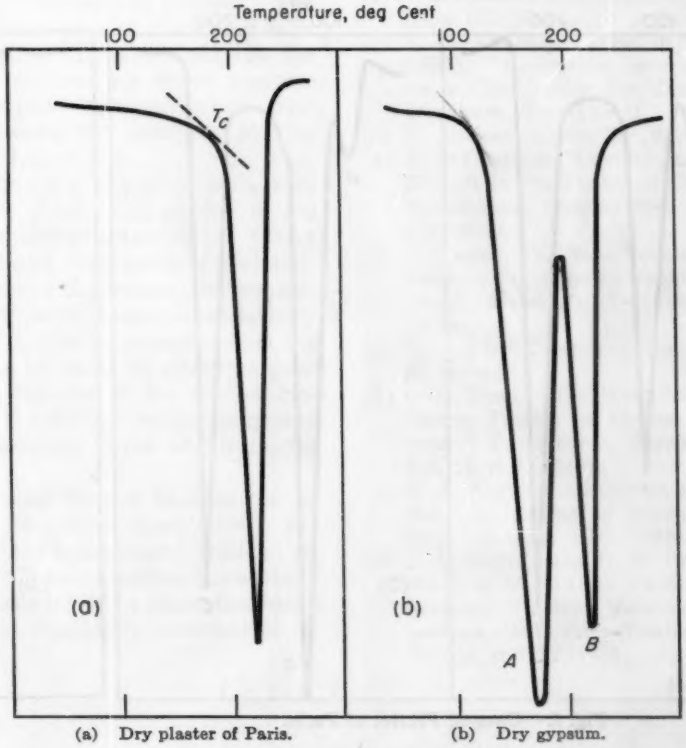
[a] Following 1 min of mixing.
[b] Includes vibration time but not the initial mixing time of 1 min.

Figure 3 is a graphical presentation of these data.

Differential Thermal Analysis of Gauged Plaster of Paris:

In order to determine the role of the mixing water and follow the course of hydration of the hemihydrate to the dihydrate, a differential thermal analysis was made of several standard mixes, each of which was allowed to remain in contact with its mixing water for a different length of time before analysis.

Differential Thermal Analysis Reference Samples.—Figure 4(*a*) is the thermogram of dry gauging plaster (plaster of Paris).



(a) Dry plaster of Paris. (b) Dry gypsum.

Fig. 4.—Reference Samples.

The large endotherm (T_c = 185 C)[5] represents the reaction:

$$CaSO_4 \cdot \tfrac{1}{2}H_2O = CaSO_4 \text{ (soluble anhydrite)} + \tfrac{1}{2}H_2O$$

Figure 4(*b*) shows the decomposition of gypsum.

Endotherm *A* (T_c = 125 C):

$$CaSO_4 \cdot 2H_2O \text{ (gypsum)} = CaSO_4 \cdot \tfrac{1}{2}H_2O \text{ (plaster of Paris)} + 1\tfrac{1}{2}H_2O$$

Endotherm *B* (T_c = 190 C):

$$CaSO_4 \cdot \tfrac{1}{2}H_2O \text{ (plaster of Paris)} = CaSO_4 \text{ (soluble anhydrite)} + \tfrac{1}{2}H_2O$$

Differential Thermal Analysis Sample No. 1.—The standard mix was prepared (stirred and mixed thoroughly for 1 min) and then allowed to remain undisturbed for 2 min. A small portion of the mix (10 to 20 g) was immediately washed thoroughly first with absolute ethyl alcohol to remove free water and then with pure acetone. The mix was spread out, in a thin layer, on absorptive paper until the acetone had evaporated. The entire washing and drying operation was accomplished in somewhat less than 10 min. This dry material was pulverized in a mortar, packed in the active-sample well of the analyzer crucible, and subjected to differential thermal analysis. Figure 5(*a*) is the thermogram produced by this material.

[5] T_c, characteristic temperature: temperature at 45-deg tangent to "knee" of endotherm. This is an arbitrary method (9) found to be better than the commonly used peak temperature which varies considerably with sample weight and heating rate.

Endotherm *A* (T_c = 55 C) is due to the volatilization of residual acetone (bp 56.5 C).

Endotherm *B* (T_c = 90 C) is of particular interest since it is very unlikely that it represents volatilization of free (uncombined or nonadsorbed) water even though free water does give a similar endotherm.

It is the author's belief that this endotherm represents the removal of adsorbed water from the highly developed surface and the intermicronic channels of the hemihydrate particles. Such water, as time progresses, might well penetrate into intermolecular or interionic interstices and bring about hydration and the formation of dihydrate crystals.

Endotherm *C* (T_c = 190 C) represents the dehydration of the hemihydrate:

$$CaSO_4 \cdot \tfrac{1}{2}H_2O = CaSO_4 \text{ (soluble anhydrite)} + \tfrac{1}{2}H_2O$$

Differential Thermal Analysis Sample No. 2.—Another portion of gauged plaster was handled in the same manner as sample No. 1 except in this case the mix was allowed to stand 10 min before washing with alcohol and acetone. The thermogram produced by this material is shown in Fig. 5(*b*).

Endotherm *A* (T_c = 65 C) represents the volatilization of a small amount of residual acetone.

Endotherm *B* (T_c = 100 C) is closely similar to *B* of Fig. 5(*a*), the significance of which has already been discussed.

Endotherm *C* (T_c = 185 C) shows the dehydration of the hemihydrate to soluble anhydrite.

A study of Fig. 5 reveals that not only is the hemihydrate unchanged chemically after a 3-min contact time with water but even after a contact time of 10 min measurable hydration has not taken place.

Differential Thermal Analysis Sample No. 3.—Figure 6(*a*) is the thermogram of a sample taken from the mix at the age of 30 min. Inasmuch as the initial set had already occurred, the sample was crushed prior to washing with alcohol and acetone.

Endotherm *A* (T_c = 90 C) is similar to those produced in Fig. 5 in this temperature range.

Endotherm *B* (T_c = 130 C) represents the partial dehydration of some dihydrate:

$$CaSO_4 \cdot 2H_2O = CaSO_4 \cdot \tfrac{1}{2}H_2O + 1\tfrac{1}{2}H_2O$$

This is the first indication of the presence of dihydrate.

Endotherm *C* (T_c = 190 C) represents the dehydration of hemihydrate to soluble anhydrite. The fact that the amplitude of this endotherm is larger than that of *B* indicates that the heat effect of *C* is due to dehydration of hemihydrate produced from the partial dehydration in *B* plus the portion of the original hemihydrate which is still unhydrated. For the normal size rela-

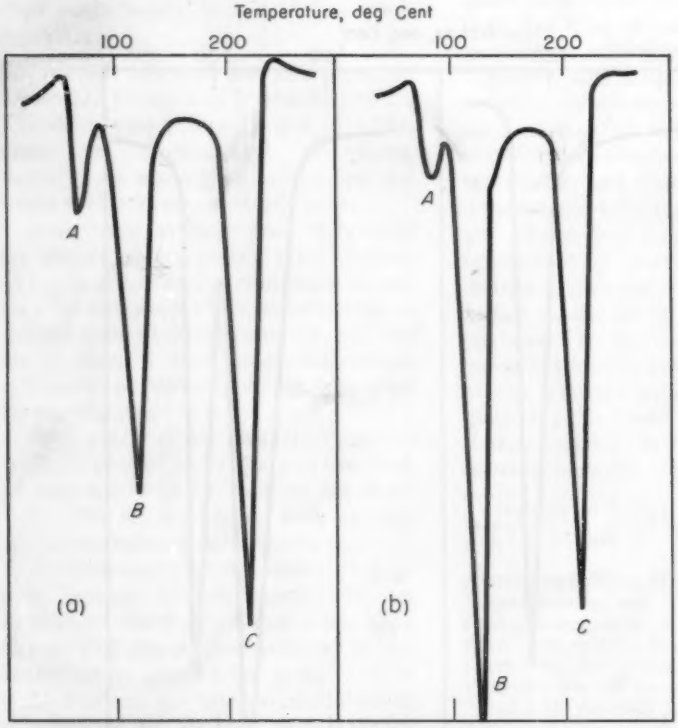


Fig. 5.—Gauged Plaster of Paris.

(a) 3-min contact time with water.
(b) 10-min contact time with water.

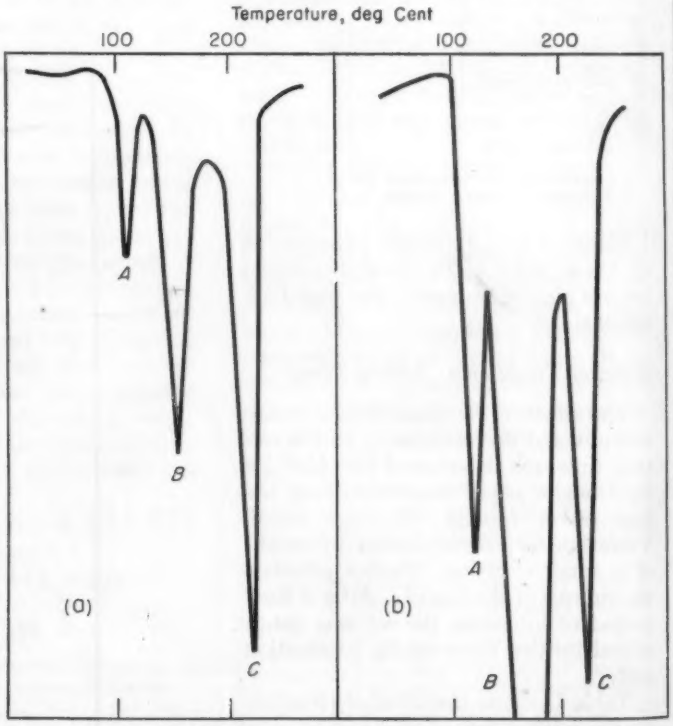


Fig. 6.—Gauged Plaster of Paris.

(a) 30-min contact time with water.
(b) 45-min contact time with water.

tionship existing between the dihydrate to hemihydrate and the hemihydrate to anhydrite endotherms, see Fig. 4(*b*).

Differential Thermal Analysis Sample No. 4.—A batch of gauged plaster was prepared in the usual manner and allowed to stand 45 min before analysis. Washing with alcohol and acetone was done prior to analysis. The mix had hardened and a sample for thermal analysis was first pulverized in a mortar, as in sample No. 3. Figure 6(*b*) is the thermogram produced by this sample.

Endotherm *A* (T_c = 95 C) represents some adsorbed or free water.

Endotherm *B* (T_c = 135 C) represents the reaction:

$$CaSO_4 \cdot 2H_2O = CaSO_4 \cdot \tfrac{1}{2}H_2O + 1\tfrac{1}{2}H_2O$$

Thus it can be seen that the hemihydrate has hydrated.

Endotherm *C* (T_c = 200 C) represents the dehydration of the hemihydrate (produced in *B*) to soluble anhydrite.

Differential Thermal Analysis Sample No. 5.—A sample of gauged plaster was spread out to a thickness of about ¼ in. on a glass plate and allowed to stand undisturbed for 7 days at a temperature of 21 C and a relative humidity of 50 per cent. Figure 7 is the thermogram produced by this material.

Endotherm *A* (T_c = 90 C) gives the indication of the presence of two overlapping endotherms by the change in curvature at approximately 120 C. The first portion is a result of free or adsorbed water removal whereas the second larger portion is due to the partial dehydration of gypsum to hemihydrate.

Endotherm *B* (T_c = 190 C) represents the dehydration of the hemihydrate (from *A*) to soluble anhydrite.

Conclusions

The effect of various admixes on the initial setting time of gypsum plaster indicates the colloidal nature of the system. The addition of even small amounts of cations accelerates the set by increasing lyosorption and gelation. This effect increases with increasing valency of the cations (Hofmeister Ionic Series).

The effect of dispersing agents is that of retardation. Capillary active substances, such as the dispersing agents used in this study, concentrate and orient at the water-hemihydrate interface (similar to the dipolar orientation of soap molecules at an oil-water interface) to the extent that lyosorption is inhibited and consequently adsorption of water by the hemihydrate is delayed.

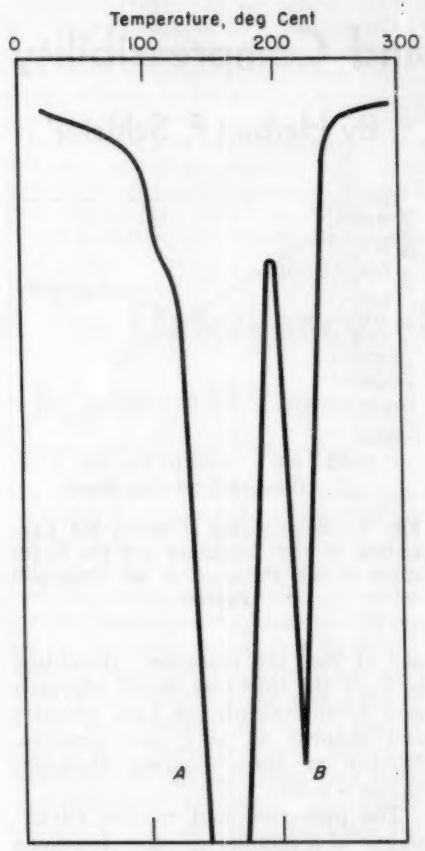


Fig. 7.—Gauged Plaster of Paris—Aged 7 Days.

The effect of mechanical vibration is to accelerate the set, or in other words, to increase the rate of gelation. The explanation of such an effect may lie in the kinetics of the action whereby the dispersed particles are driven together by mechanical agitation which constantly renews the interface, causing increased lyosorption.

The retarding action of such substances as gelatin and alcohol is due to the protective action of the former and the dehydrating power of the latter. In the case of the gelatin, the hemihydrate particles are encased in a relatively strong hull, that is, protected from the adsorption of water necessary to gelation. In the case of the alcohol, lyosorption is inhibited by the stripping-off or prevention of the adsorbed layer of water.

Differential thermal analysis can be used to determine qualitatively the extent of the hydration of hemi- to dihydrate. It indicates that the water of unset plaster is held by adsorption forces and is not chemically combined as dihydrate.

The mechanism whereby plaster of Paris sets and later hardens when gauged with water is believed, by the author, to be as follows:

1. Water is adsorbed by the hemihydrate due to residual crystal forces inherent in the structural makeup of the lattice.
2. Water enters intermicronic channels, an adsorption complex is formed with increasing solvation, and a gel structure results, giving the initial set. The water at this stage is held by physical forces.
3. Intramicellar swelling occurs and water enters the interior of the micelles *via* intermolecular or interionic channels.
4. A merging of physical adsorption into chemosorption now gradually occurs and chemical hydration results with the evolution of heat and the formation of minute gypsum crystals. These crystals gradually form a hardened interlocking mass giving the final set. Adsorbed water in many cases still remains in an aged plaster (9) and there is some indication that cycles of partial dehydration and hydration occur in finish coat plasters prepared from gauged plaster of Paris and hydrated lime.[8]

[8] Unpublished data from continuation of studies reported in Reference (9).

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Thickness and Compressibility of Fabrics

By Herbert F. Schiefer[1]

EDITOR'S NOTE.—This is a synopsis of a talk given by Mr. Schiefer at the Fall, 1952, meeting of ASTM Committee D-13 on Textile Materials, in New York City.

THERE is more and more interest in characterizing fabrics according to feel and hand. Important physical attributes that affect the feel and hand are compressibility and thickness, especially at low pressures. Thickness measurements at pressures in the range of 0.005 to 2.0 psi are routinely made with the Schiefer compressometer (1)[2]. Recently there has been considerable interest in thickness measurements at even lower pressures. Such measurements, however, present some difficulty. It seemed worth while, therefore, to give some consideration to the quantitative relationship between thickness and pressure over the pressure range that can be readily covered with the compressometer, namely, 0.005 to 0.10 psi using a presser foot 5 in. in diameter; and 0.10 to 2.0 psi using a presser foot 1 in. in diameter, with the hope that fairly reliable estimates of the thickness for pressures between 0 and 0.005 psi can be computed.

In Fig. 1 are plotted the thickness values of a typical unnapped fabric against pressure using logarithmic coordinates. The thickness, T, corresponding to the pressure, P, can be represented by Eq 1:

$$\log T = m \log P + b \quad \ldots\ldots (1)$$

where m and b are constants. Another form of this relationship is Eq 2:

$$T = T_1 P^{-C_1} \quad \ldots\ldots (2)$$

where T_1 and C_1 indicate the thickness and compressibility at unit pressure, respectively. The compressibility, C, at any pressure, P, defined by Eq 3, is then given by Eq 4:

$$C = -\frac{1}{T}\frac{dT}{dP} \quad \ldots\ldots (3)$$

$$C = C_1/P \quad \ldots\ldots (4)$$

Equation 2 appears to be valid for quite a variety of fabrics for pressures ranging from 0.005 to 2.0 psi. For some fabrics, however, it may be valid for only a smaller range of pressures. The primary disadvantage of Eq 2 is that it fails to represent the thickness at high

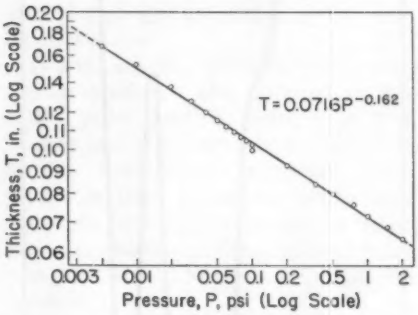

Fig. 1.—Relationship Between the Logarithm of the Thickness and the Logarithm of the Pressure of an Unnapped Fabric.

and at very low pressures. According to Eq 2 the thickness would approach zero asymptotically at high pressure and infinity at very low pressure. Neither of these limiting thickness values is valid.

The properties and relative advantages of a number of other functions were considered, including the following:

$$T(P + h) = a \text{ or } 1/T = mP + 1/T_0 \quad \ldots (5)$$

$$(T - k)(P + h) = a \text{ or } T = k + \frac{a}{P+h} \quad \ldots (6)$$

$$T^n(P + h) = a \text{ or } 1/T^n = mP + 1/T_0 \quad \ldots (7)$$

$$T(P^n + h) = a \text{ or } 1/T = mP^n + 1/T_0 \quad \ldots (8)$$

Equation 6 has been considered in detail by Bogaty, *et al* (2), and they applied it very successfully to fabrics of different surface characteristics by assuming that $h = 0.05$ psi.

Equation 8 represents the thickness data of some fabrics very well for the special case when $n = \frac{1}{3}$, that is, when

$$1/T = mP^{1/3} + 1/T_0 \quad \ldots\ldots (9)$$

Equation 9 indicates a straight-line relationship between the reciprocal of the thickness and the cube root of the pressure. Figure 2 shows results for a typical blanket fabric. The slope of this line is given by m and the intercept on the $1/T$ axis, that is, when P is zero, is given by $1/T_0$ where T_0 is the thickness at zero pressure. The values of m and T_0 are given by Eqs 10 and 11:

$$m = \frac{T_1 - T_2}{T_1 T_2 (P_2^{1/3} - P_1^{1/3})} \quad \ldots\ldots (10)$$

$$1/T_0 = 1/T_1 - mP_1^{1/3} \quad \ldots\ldots (11)$$

where T_1 and T_2 are the measured thickness values of a fabric at pressures P_1 and P_2, respectively. The value of T_0 is a good estimate of the thickness of a fabric at zero pressure. After the values of m and T_0 have been evaluated for a fabric, then its thickness, T, at any pressure, P, in the applicable pressure range can be readily computed from Eq 12:

$$T = \frac{1}{mP^{1/3} + 1/T_0} = \frac{T_0}{mT_0P^{1/3} + 1} \quad \ldots\ldots (12)$$

The compressibility, C, at the pressure, P, can be computed from this pressure and the corresponding thickness, T, from Eq 13:

$$C = \frac{T_0 - T}{3T_0P} \quad \ldots\ldots (13)$$

Equation 9 has the following advantages over Eq 2: (1) in general, it is applicable over a wider range of pressure, (2) the thickness values of compressible fabrics, such as blankets, can be represented better over the same pressure range, and (3) the thickness values extrapolated to zero pressure are more reliable.

In applying Eq 9 to thickness data of fabrics for the purpose of extrapolating to zero pressure it is in general better to fit the equation to the data at two low pressures, for example, 0.01 and 0.10 psi, than to two higher pressures, such as 0.05 and 1.0 psi.

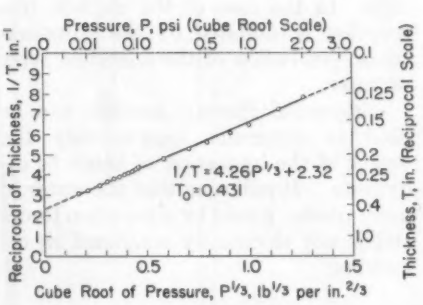

Fig. 2.—Relationship Between the Reciprocal of the Thickness and the Cube Root of the Pressure of a Blanket.

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[1] Physicist, Textiles Section, National Bureau of Standards, Washington, D.C.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

Papers on Soaps and Other Detergents

EDITOR'S NOTE.—At the March, 1953, meeting of ASTM Committee D-12 on Soaps and Other Detergents the 5 papers printed below were presented. In addition to these 5 papers, Bibliographical Abstracts of Methods for Analyses of Synthetic Detergents, prepared by R. Bernstein, Philadelphia Naval Shipyard, were also presented. This Bibliography is being published in a separate volume form as *Special Technical Publication No. 150.* Copies may be secured from ASTM Headquarters.

It is planned to issue a separate reprint containing the 5 papers in this issue of the ASTM BULLETIN as well as a paper by J. D. McGilvery on "The Temperature Rise Test to Determine the Relative Amounts of Phases I and II in Sodium Triphosphate," which appeared in the July, 1953 issue, ASTM BULLETIN, No. 191. Mr. McGilvery's paper is included as of interest to the readers of the papers on soaps and other detergents.

A Dynamic Test for Detergency of Hard Surfaces

By Manuel N. Fineman[1]

THE excellent bibliographies of Harris (1)[2] testify to a rapidly growing interest in hard surface detergency, but they also reveal the confusion that exists. There are innumerable test methods, test soils, and criteria for judging performance, none of which is accepted as standard.

It is not surprising that such a diversity of techniques should exist. Cleaning methods vary with the piece to be cleaned as well as with the kind of soil encountered. Consequently, most investigators have designed their test procedures to simulate practical conditions encountered in their own fields, and procedures which might be generally applicable as standards have been few.

One such technique is the basis for Federal Specification P-C-431. It involves use of a windshield-wiper type of apparatus for removal of an oily soil mixture from painted metal panels and determination of detersive efficiency by reflectance measurements. However, it has many limitations. By its very nature, the test cannot be conducted at the elevated temperatures which more closely approximate conditions of use of the detergents; preparation of painted panels is very critical; data obtained are often meaningless, since they do not correlate with field experience, and reproducibility of these data is erratic.

This procedure involves abrasion of a soiled surface; other techniques require agitation; still others are static. In all these cases, estimation of residual soil has been a problem. Morgan and Lankler (2) used a fluorescent dye in the soil; Spring (3) and Lindford (4) claimed that the water break method was eleven times more sensitive than the dye method.

More recently, it has been shown that use of a radioactive tracer in the soil produced ten times the sensitivity of the water break test, 110 times the sensitivity of the dye method (5). However, this remarkable sensitivity may be greater than required or desired. There are far too many variables in an actual cleaning operation to warrant the ultimate in sensitivity in the test method unless that method can be correlated exactly with field experience. Practical significance of the test data, and their reproducibility, are really the major considerations, and it is in these respects that so many methods fail.

The detergency test procedure developed at Rohm & Haas does not have the high sensitivity of the radioactive tracer technique, but it is rapid, simple and, above all, meaningful and reproducible. In addition, its flexibility has permitted study of the variables in the detergency process and observation of interactions between substrate, soil, and surfactant which might otherwise have escaped detection. Some of these interactions have already been reported (6). The test permits use of a variety of soils on a variety of substrates and provides reproducible conditions of temperature, agitation, and time.

PROCEDURE

The method is similar in principle to that used by Reich and Snell (7) for qualitative estimation of detergency in their studies of diphase metal cleaners.

In essence, it involves agitation of clean and soiled substrates in detergent solutions in a standard Launderometer; and, in a single operation, permits rating of detersive efficiency, soil redeposition, and soil suspending action of the detergent.

Metal, ceramic tile, glass or plastic substrates, having dimensions approximating 1 by 1 by $\frac{1}{16}$ in., were cleaned with a light abrasive cleanser, or in a ball mill, dried, and soiled with an oily-carbon paste. The paste consisted of one part of fine carbon black (Philblack O[3]) mixed intimately with two parts of aliphatic mineral oil (Atreol 9[4]) and was applied by spatula to the substrates and to the inside surface of the glass caps of the Launderometer jars. Soil was applied as uniformly as possible and averaged about 0.10 g on the substrates and 0.13 g on the glass caps. Coefficient of variation for amount of soil applied was found, by weighing, to be about 25 per cent, but in spite of this apparently large variable it will be shown that reproducibility of the data is adequate.

Detergent solutions of varying concentration were made up to a volume of 200 ml each and preheated in the jars to the required temperature. Five concentrations were selected (1.0, 0.3, 0.1, 0.03, and 0.01 per cent) to encompass the useful range of the detergent and to permit suitable plotting of performance against logarithm of concentration. Temperature was usually 140 F.

Two soiled and two clean substrates were added to the jars which were then sealed with the soiled glass caps. The jars were mounted in the Launderometer and rotated at 42 rpm for 10 min. After washing, the solutions were separated from the substrates for subsequent determination of optical density. The substrates and glass caps were rinsed briefly in tap water and spread out for visual inspection and comparison with a set of standards.

RATINGS

As shown in Fig. 1, cleanliness of the substrates was rated by points ranging from five for "completely clean" to one for "completely soiled." These ratings could be further subdivided to describe intermediate conditions of soiling in half units. The sum of the ratings of the two soiled substrates (S), at all concentrations, could be converted to describe percentage efficiency of the deter-

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Research Laboratories, Rohm & Haas Co., Bridesburg, Pa.

[2] The boldface numbers in parentheses refer to the list of references appended to this paper.

[3] Product of Phillips Petroleum Co.

[4] Product of Atlantic Refining Co.

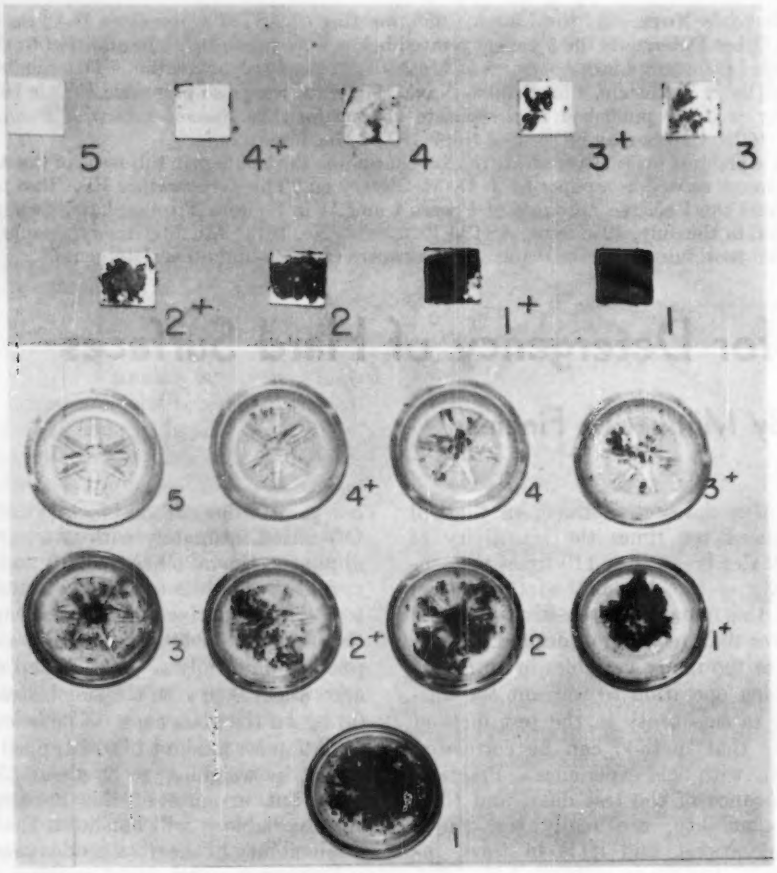

Fig. 1.—Visual Ratings of Substrates.

gent in removing soil; similarly, ratings of the two clean substrates (C) describe percentage efficiency of the detergent in preventing redeposition of soil. The average of both these factors represents the over-all efficiency of the surfactant on a particular substrate. Similar ratings for the soiled glass caps and for the clean Launderometer jars provide data on efficiency of the detergent on glass. Moreover, the data also reveal the minimum concentration at which the detergent is effective. Sample data in Table I show how these results may be reported.

The ability of the detergent to suspend the soil can be determined by photometric examination of the detergent solutions with a simple spectrophotometer. Sample optical densities are also listed in Table I. However, other work in this laboratory (8) has shown that the nature of the substrate being cleaned determines the state of subdivision of the oily-carbon soil particles and, therefore, affects the optical densities observed. Consequently, these values may be useful only as a secondary indication of detersive efficiency, but not as a primary factor.

TABLE I.—DETERSIVE EFFICIENCY OF TRITON X-100[a] ON STAINLESS STEEL.

Detergent	Visual Ratings				Summary			
Concentrations, per cent	C		S		Redeposition Prevention, per cent	Soil Removal, per cent	Over-all Efficiency, per cent	Optical Densities
1.0	5	5	5	5	99	79	89	66
0.3	5	5	5	5				28
0.1	5	5	4+	4+				24
0.03	5	4+	4+	3+				7
0.01	5	5	1	1+				1

[a] Triton Surface Active Agents are products of Rohm and Haas Co.

TABLE II.—STATISTICAL ANALYSIS OF VISUAL RATINGS.

Surfactant	Cleaning of Soiled Substrates, per cent		Prevention of Soil Redeposition, per cent		Over-all Detergency Score, per cent	
	$\bar{X}$	σ	$\bar{X}$	σ	$\bar{X}$	σ
Triton X-100	79.2	4.68	96.9	1.41	88.1	2.69
Triton 770 Conc.	62.8	4.24	79.1	3.40	70.9	3.15

Precision of the Test

In order to evaluate the test data, a report on their reproducibility and correlation with experience follows.

Certain aspects of the test, such as application of soil to the substrates and estimation of visual ratings, are highly subjective and their reliability depends upon the experience and skill of the operator. Over the past two years at Rohm & Haas it has been found that a fairly high degree of proficiency may be expected from reasonably skillful technicians after a modest training period.

This is borne out by the data in Fig. 2 which describe the results of seven replicate determinations for each of two surfactants. The substrates were glass, mild steel, and nylon. In this graph the over-all percentage detersive efficiency is reported as a bar consisting of two parts. The black part describes the contribution of the cleaning factor to over-all efficiency and was calculated from ratings of soiled substrates; the white portion was calculated from ratings of clean substrates and represents the efficiency of the detergent in preventing redeposition of soil on clean substrates. A brief statistical analysis of these data is reported in Table II in which arithmetic averages, $\bar{X}$, and standard deviations, σ, are listed. Coefficients of variation for over-all detersive efficiency are reported in the graph and are shown to be less than 5 per cent of the averages for both surfactants, even though one was markedly superior to the other.

Figures 3 and 4 are of special interest because they reveal that not only are average values for detergency reproducible but, in addition, data obtained for performance at each concentration showed good reproducibility. Figure 3 describes performance of the nonionic, Triton X-100; and Fig. 4, of the anionic, Triton 770 conc. The latter shows a rather interesting anomaly in that detersive efficiency is at a minimum at 0.1 per cent concentration, and the reproducibility of this observation confirms that it is not accidental.

As might have been expected, precision was best where substrates were either very clean or very soiled, the widest variations occurring in the area of intermediate cleaning. Moreover, the large differences noted for detersive efficiencies at the concentrations examined suggest that the concentration range selected for this test describes the over-all performance of the surfactants quite well. The data certainly focus

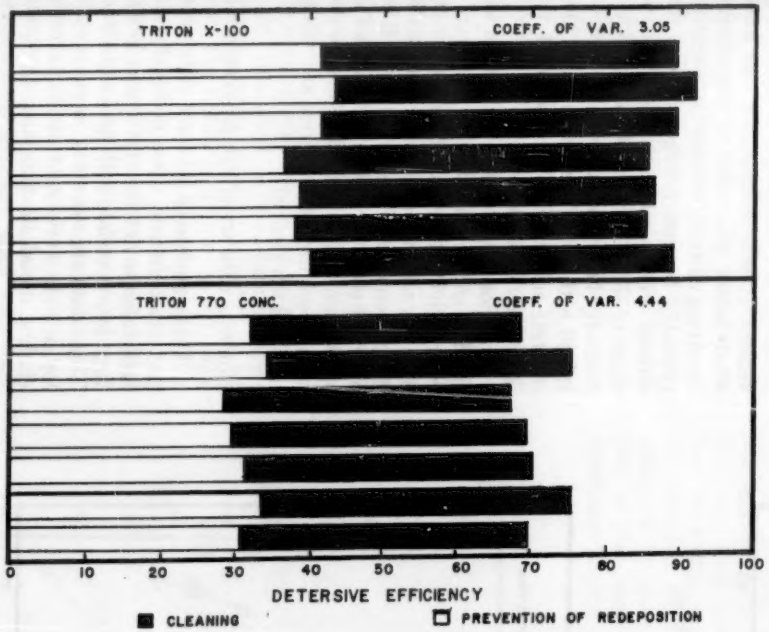

Fig. 2.—Reproducibility of Test Method.

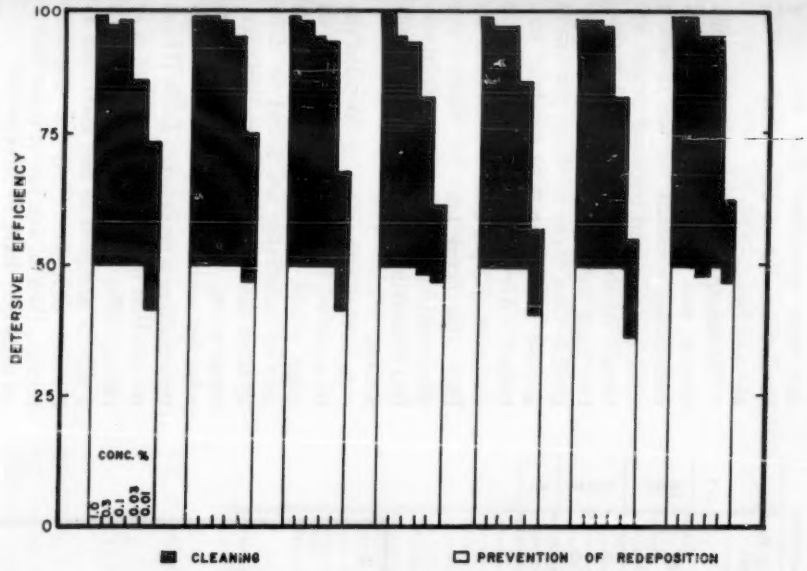

Fig. 3.—Reproducibility of Test Method at Each Concentration, Triton X − 100. Glass, steel, and nylon substrates.

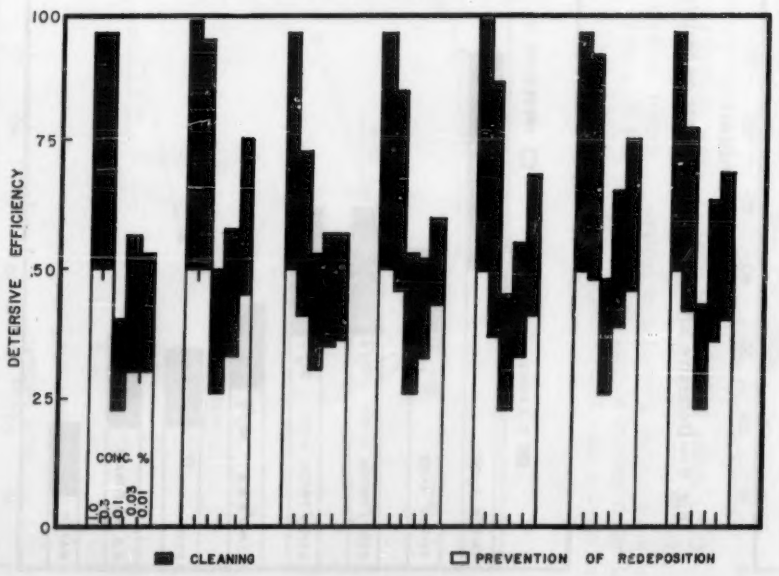

Fig. 4.—Reproducibility of Test Method at Each Concentration, Triton 770 Conc. Glass, steel, and nylon substrates.

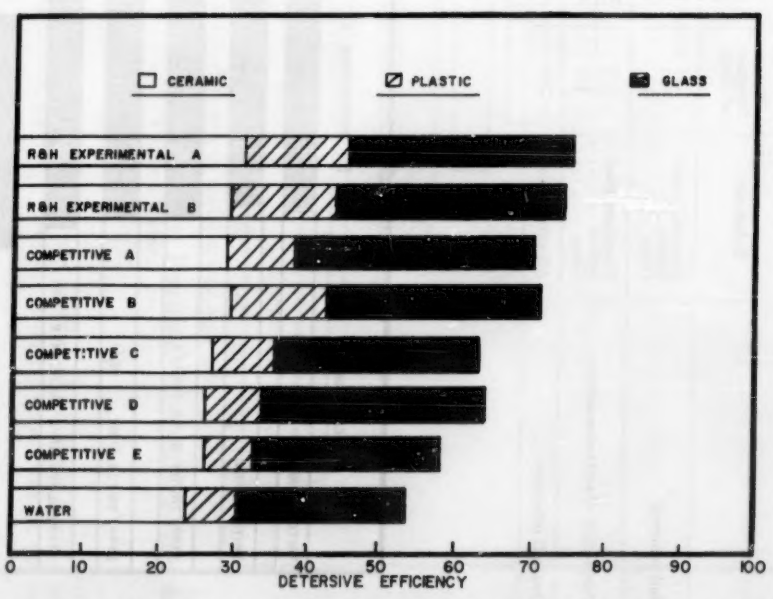

Fig. 5.—Detersive Efficiency of Low-Foaming Dishwashing Detergent Formulations.

TABLE III.—ANALYSIS OF REPRODUCIBILITY OF DUPLICATE DETERMINATIONS.
Per Cent of Cases in Various Score Difference Ranges.

	Substrate	Total Number of Cases	Score Difference Ranges, per cent			
			0	.0.5	1	>1
Soil removal	Furniture steel	141	45	26	13	16
	Nylon	121	77	22	1	0
	Glass	121	31	45	17	7
Prevention of soil redeposition	Furniture steel	141	79	16	2	3
	Nylon	117	78	21	1	0
	Glass	122	47	36	10	7
Over-all efficiency	All substrates	763	60	28	6	6

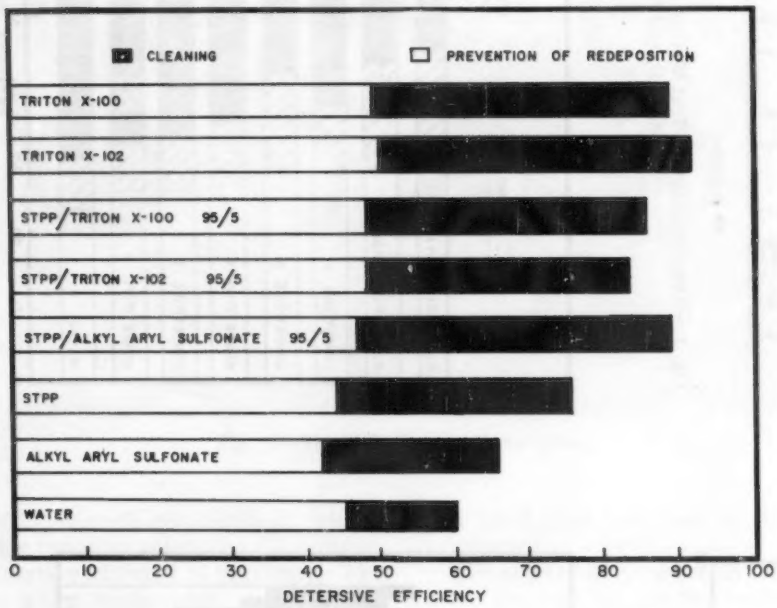

Fig. 6 —Detersive Efficiency of Surfactants on Stainless Steel.

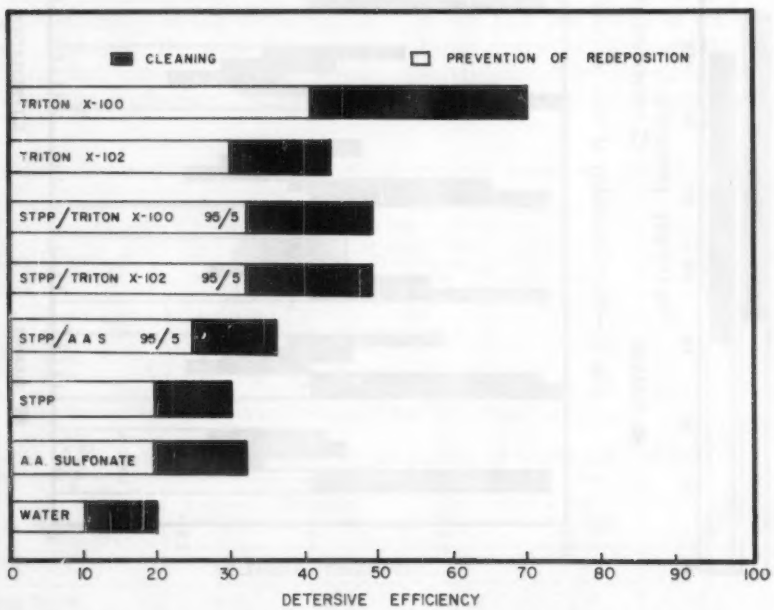

Fig. 7.—Detersive Efficiency of Surfactants on Melamine Plastic Dishware.

attention on the obvious inadequacy of any test procedure that employs a smaller number of concentrations than are used here.

The amount of soil applied to the substrates was accurately weighed and maintained constant for the fifth and sixth of the seven replicate determinations. As shown in Figs. 4 and 5, these two runs were somewhat more reproducible than those in which amount of applied soil was not as carefully controlled. Accordingly, if a coefficient of variation of 5 per cent is considered too high, this figure may be reduced and precision improved by more careful control of amount of soil applied to the substrates.

A further refinement in precision can be achieved by repeating the test in all cases where ratings of any duplicate pair of substrates are found to differ by more than some predetermined maximum score. An analysis of data compiled for several hundred duplicate determinations is reported in Table III and reveals that more than 94 per cent of all ratings differ by 1 unit or less. Thus if 1 unit is accepted as the maximum allowable difference between duplicate ratings, then an average of 6 per cent of all tests may have to be repeated.

A further reduction in the over-all coefficient of variation can thus be achieved, and this technique is now standard practice at Rohm & Haas laboratory. Again, as noted in Table II, precision of experiments involving prevention of soil redeposition was somewhat better than that of experiments involving cleaning of soiled substrates—probably because ratings of clean substrates were uniformly high whereas those of soiled substrates varied widely. Similarly better reproducibility was obtained with nylon than with either glass or steel substrates—because most ratings on nylon were low.

For those desiring the ultimate in sensitivity and, consequently, precision, a radioactive tracer can be incorporated into the soil and residual soil or soil redeposition measured accordingly. However, the essential features of this test are speed, simplicity, and reliability, so that such specialized techniques are neither required nor desired.

Correlation with Field Experience

The significance of any detergency test must depend upon comprehensive field trials to determine whether laboratory data correlate with field experience. These data are currently being compiled for a wide variety of applications including metal cleaning and degreasing, wall and floor cleaning, dishwashing, etc., but it is not yet possible to present a complete report of these trials. All

evidence to date suggests that this test method is more meaningful than those currently used for detergency evaluation. One complete field study may be reported.

Figure 5 describes the laboratory data obtained in evaluating a number of low-foaming dishwashing detergents as cleaners for soiled ceramic tile, melamine plastic dishware, and glass substrates. Here, only over-all detersive efficiency is reported and the three portions of the bar describe the performance of the detergents on each of the three substrates. Some of these samples were submitted to a consumer panel of 25 housewives who tested them in their home dishwashers and rated them according to their own preferences. The correlation between their observations and the laboratory study was very satisfactory and most gratifying.

Sample Results

During the past two years, while this method was being developed, the behavior of over twenty substrates was examined. These included materials which were relatively easy to clean such as glass, ceramic tile, stainless, furniture, passivated, and phosphatized steels, and the metals iron, brass, aluminum, copper, and zinc. Substrates which were somewhat more difficult to clean included linoleum, baked enamel, silver and the plastic materials: melamine dishware, Plexiglas,[5] polyethylene, nylon, and Teflon.[6] Behavior of some detergents on eleven of these substrates has already been reported (6).

Hundreds of detergents have been evaluated by this test. Figures 6 and 7 describe the comparative performance of seven representative detergent formulations on stainless steel and melamine dishware, respectively. The detergents included two representative nonionic surfactants with slightly different solubility characteristics, Tritons X-100 and X-102, a typical alkyl aryl sulfonate, an alkaline cleaner (sodium tripolyphosphate), three built formulations comprising 95 per cent alkaline salt and 5 per cent of each surfactant, and water.

It is apparent that all the detergents, except the alkyl aryl sulfonate, were effective on the steel; but only one of them, the nonionic Triton X-100, was effective on the hard-to-clean melamine plastic.

There are other ways in which these data may be reported. One of the best is to compare detersive efficiency of a surfactant with that of water under exactly the same test conditions. This has been done in Fig. 8, except that instead of reporting behavior on a single substrate, these bars represent the average values of results obtained on eleven different metal, plastic, and glass substrates. The bars describe over-all detersive performance in terms of percentage efficiency *greater* than that of water.

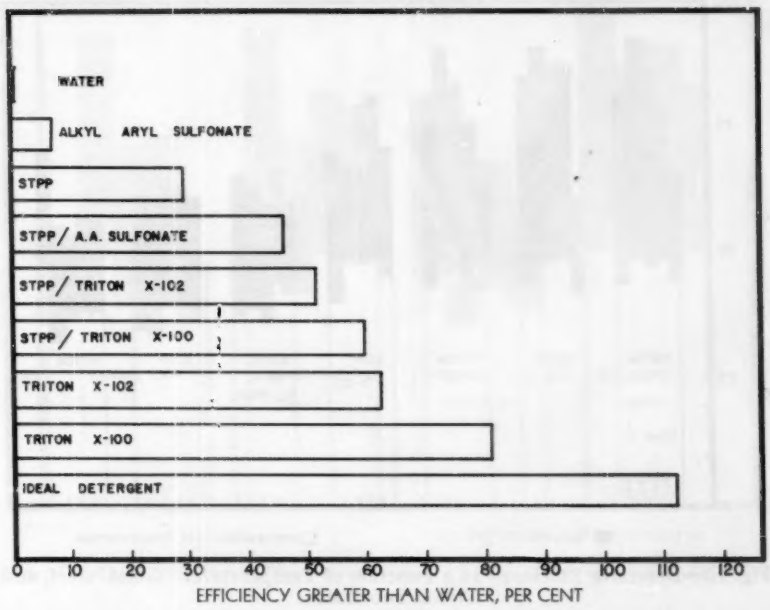

Fig. 8.—Comparison of Detergents in Terms of Percentage Efficiencies Greater than That of Water.

It is apparent that neither the alkyl aryl sulfonate nor the alkaline salt was much better than water alone. When these two were mixed, a synergistic effect was noted; but total efficiency was still less than that obtainable with the nonionics or nonionic-alkaline blends. One of the nonionics, Triton X-100, came close in performance to that of the ideal material which would have a perfect score on *all* substrates at *all* concentrations.

For the formulator such a graph is of immeasurable practical value. Moreover, it is highly significant statistically, since it represents the averages of 55 duplicate determinations, 110 in all, for each surfactant.

Cost Comparisons

The test method offers another advantage in that the concentration required to achieve a certain standard of detergency may be readily determined. Consequently, cost comparisons can be

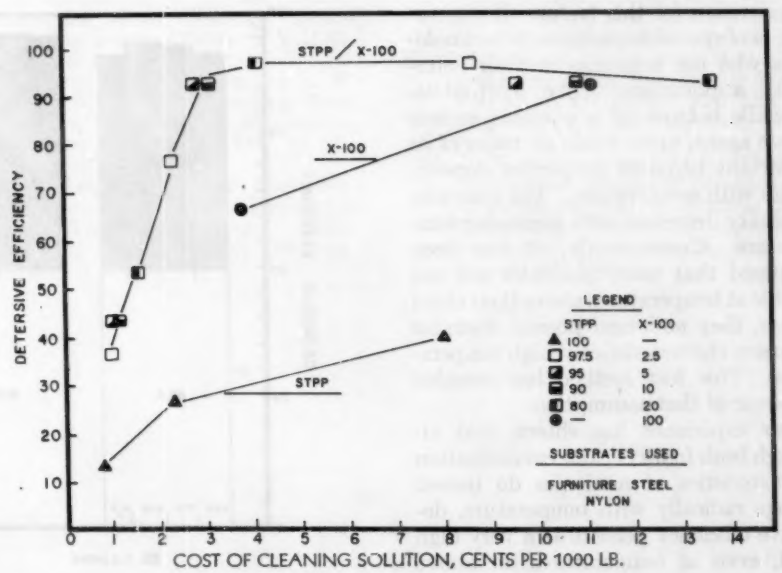

Fig. 9.—Detersive Efficiency per Unit Cost.

[5] Product of Rohm & Haas Co.
[6] Product of du Pont Co.

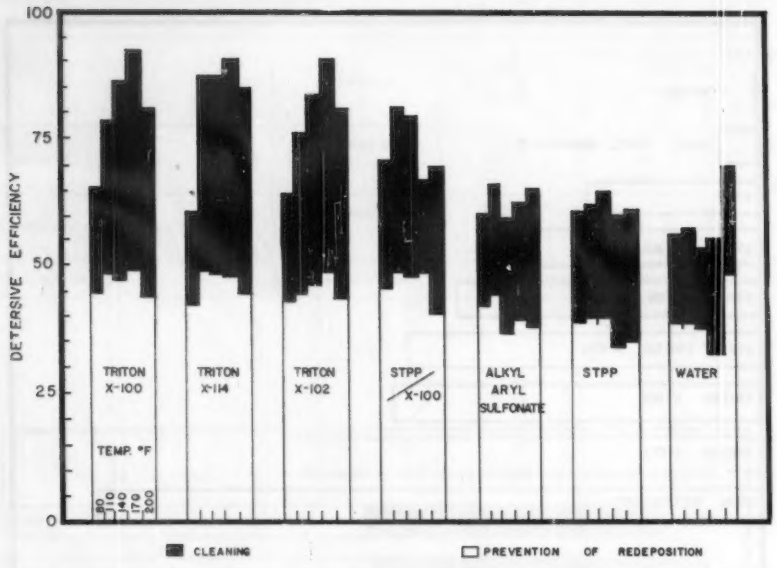

Fig. 10—Detersive Efficiency as a Function of Temperature. Glass, steel, and Nylon Substrates.

made and detergents compared on a money-value basis.

This is demonstrated graphically in Fig. 9 which describes the performance of Triton X-100, the alkaline salt, and blends of these two as a function of cost. Blends of varying ratio were tested, as indicated, but all of these seemed to follow the same performance : cost curve.

The test reveals that blends of the type examined can yield superior detergency per unit cost than either the nonionic or alkaline salt alone. In other situations the test could reveal which blends or formulations produce the optimum in money value.

Effect of Temperature

Temperature is a most important variable in any detergency operation; nevertheless the windshield-wiper test makes no provision for this factor. Temperature is of special importance to technologists who use nonionics in their detergency applications. The hydrophile-lipophile balance of a nonionic surface active agent, upon which so many of its important physical properties depend, varies with temperature. For example, solubility decreases with increasing temperature. Consequently, it has been supposed that since nonionics are not soluble at temperatures above their cloud points, they no longer possess desirable detersive characteristics at high temperatures. This test method has revealed the error of that assumption.

Our experience has shown that although both foam (9) and emulsification characteristics of nonionics do indeed change radically with temperature, detersive efficiency persists at a very high level, even at temperatures far above the cloud point. This is shown in Fig. 10 which describes the performance of three nonionics, Tritons X-100, X-114, and X-102, a nonionic alkaline blend, an anionic, an alkaline salt, and water at each of five temperatures ranging from 80 to 200 F. All three nonionics showed optimum performance at 170 F, at which temperature Triton X-100 was 25 F above its cloud point. Triton X-114, a low-foaming nonionic with a cloud point of about 70 F, also showed optimum detergency at 170 F—100 F above its cloud point. Moreover its detersive efficiency at these high temperatures was comparable to that of the more soluble Tritons. The other detergents showed very little variation as a function of temperature.

Soils

The wide variety of soils encountered in practical cleaning operations include, among others, greases, machine oils, buffing compounds, carbon, carbonized oils, corrosion products, waxes, food, and food residues, etc. (10). Rather than investigate the applicability of the dynamic detergency test to all of these, it was considered most appropriate to select for examination certain types of soils and then determine which of these was most desirable as a standard soil. A preferred standard for evaluation of detergents would be a soil which produced the widest spread between efficiency of detergents and that of water.

Food type soils were selected for characterization of dishwashing detergents, and oily-carbon soils for evaluation of metal cleaners and degreasers. In addition, the appropiate substrates were selected to simulate application conditions. Thus, ceramic tile was used with the food type soils, and mild steel with the oily carbon materials. Nylon was also investigated because it is generally difficult to clean, and is similar in many respects to plastic dishware. As always, the glass caps of the Launder-ometer jars were also soiled to yield data on that substrate.

Figure 11 describes the performance of Tritons X-100 and 770, an alkyl aryl sulfonate, and water on four selected food type soils. Milk was representative of proteinaceous soils; cooked rice, of starchy soils; and lard, of fatty soils. The food mixture consisted of egg, lard, flour, milk, and peanut butter as described by Gilcreas and O'Brien (11).

It is apparent that, except for the lard and egg, the food type soils were rel-

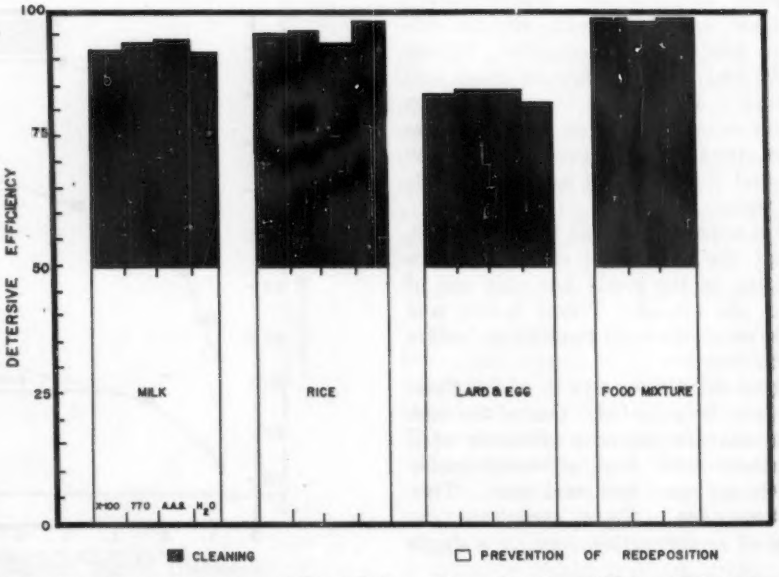

Fig. 11.—Characterization of Food Soils. Glass, Steel, and Nylon Substrates.

atively easily removed by all the surfactants and by water. Even with lard and egg, differences between performance of surfactants and that of water were too small to make this soil useful as a standard for evaluating detersive efficiency.

The oily-carbon soils included our standard soil; the latter baked on substrates at 260 F for 1 hr to simulate some conditions where carbonizing of oil might be a problem; a 1.5:1 mixture of high viscosity oil (Sun Heavy Oil, 150 Saybolt sec at 250 F) and carbon black, and a metallic brown soil. The last is the standard soil used in the windshield-wiper test and was composed of metallic brown, kerosine, carbon tetrachloride, liquid petrolatum, lubricating oil, and hydrogenated vegetable shortening. It was baked on the substrates at 220 F for 30 min.

Figure 12 reveals that although the soil containing the viscous oil was somewhat more difficult to remove than the normal soil, the latter showed the largest spread between performance of the detergents and that of water. Consequently it was selected as our standard. Baking this soil made it more readily removable by water. The metallic brown soil showed little differences between behavior of the surfactants and that of water.

The relative order of efficiency of the detergents was the same for the viscous soil as for the normal soil, thus suggesting that the latter may indeed prove useful as a standard. However, in interpreting data obtained by this test it must be borne in mind that they are meaningful only for the particular soil and particular test temperature employed. The data are especially useful for comparative purposes and their extrapolation to other soils or to other temperatures should be avoided.

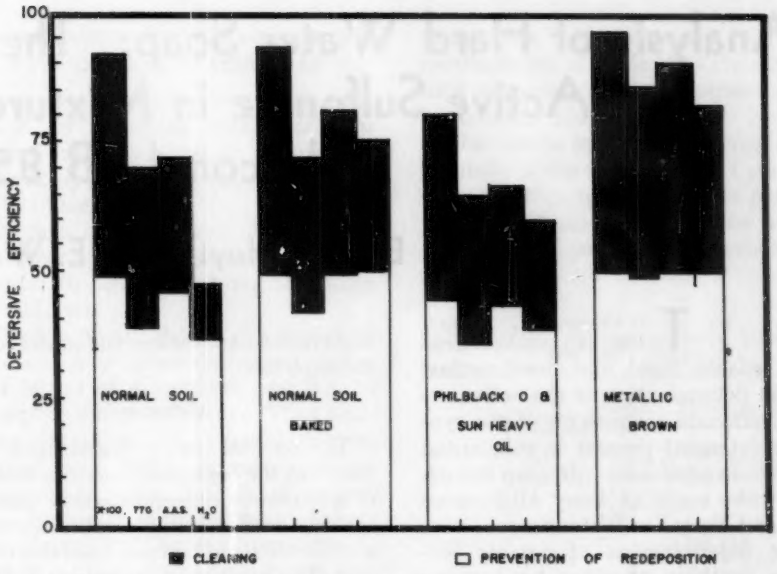

Fig. 12.—Characterization of Oily-Carbon Soils. Glass, steel, and nylon substrates.

Summary

A simple and meaningful new test method for determining the efficiency of detergents in cleaning a wide variety of surfaces has been developed. It involves agitation of clean and soiled substrates in a Launderometer, and in a single operation, permits rating of detersive efficiency, soil redeposition, and soil suspending action of the detergent.

Statistical data are reported describing the reproducibility of the test method, and the effects of variations in the temperature of the test and in soil composition are also considered.

Acknowledgments:

The author wishes to express his sincere appreciation for the many valuable comments and suggestions of A. C. Nuessle in whose laboratory this work was performed, for the assistance of Miss Phyllis J. Kline in obtaining the data reported here, and for the assistance of Harold L. Greenwald in the statistical compilations.

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Analysis of Hard Water Soap: The Direct Determination of Active Sulfonate in Mixtures of Soap and Nacconol RB 85

By L. F. Hoyt and J. E. Walter[1]

THERE exists a real need for a reliable, rapid, and direct method for the determination of the active organic sulfonate components of the synthetic detergent present in substantial amounts in admixture with soap in such hard water soaps as Army All-Purpose Soap and Navy Sea Water Soap.

The determination of organic sulfonate in these or other hard water soaps by difference is slow, laborious, and subject to error. Four separate analytical procedures are involved: (1) total alcohol soluble matter, (2) anhydrous salt-free soap, (3) free fatty matter that is petroleum ether extract, and (4) sodium chloride must be determined. The per cent of synthetic detergent (organic sulfonate) is arrived at by deducting the sum of (2), (3), and (4) from (1).

The authors have found that the organic detergent content in mixtures of commercially important detergents of the alkyl aryl sulfonate type, or of the higher alkyl ester types, with soaps may be determined quickly and directly in the presence of soap by a single titration with a standardized cationic detergent solution, using an adaptation of the method of Barr, Oliver, and Stubbings.[2]

No special laboratory apparatus or instruments are required, no tedious extractions are involved, and no separation of the organic sulfonate from soap is necessary. Since the titration is best carried out at a pH of about 5, any soap originally present is decomposed and does not interfere. Nonionic detergents, if present, are without effect on the titration.

It should be emphasized, however, that not all organic sulfonates can be determined by this method. The simple aryl sulfonates like sodium toluene sulfonate or sodium naphthalene sulfonate do not react at all with cationic detergents, and some types of surface-active agents such as the short chain dialkylated naphthalene sulfonates react incompletely.

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[1] New Products Division, National Aniline Division, Allied Chemical and Dye Corp., Buffalo, N. Y.

[2] T. Barr, J. Oliver, and W. V. Stubbings, "The Determination of Surface Active Agents in Solution," *Journal*, Soc. Chemical Industry, Vol. 67, p. 45 (1948).

METHOD

The method used is based upon the fact that the organic sulfonate or sulfate of a synthetic detergent reacts quantitatively with a suitable cationic detergent forming an inert and insoluble complex. The titration is carried out in very little dilute solution with bromphenol blue as a transition indicator in a two-phase system of water and chloroform. The indicator used forms with the cationic detergent a complex, colored deep blue and soluble in chloroform. Hence, as soon as a trace of excess cationic detergent is available, its presence is revealed, as the indicator (initially in the aqueous phase) begins to migrate into the chloroform layer. As little as 0.05 ml of a 0.002 *N* solution of cationic detergent will initiate this transition.

The cationic surface-active agents Hyamine No. 1622, Cetab, and Roccal (the latter sold as a 10 per cent solution) have been found satisfactory in this method. Suitable concentrations for the dilute solutions of the cationic detergent to be standardized for use as the titrating agent are 0.6 to 0.75 g per liter of Cetab and Hyamine No. 1622 or 5 g per liter of the commercial 10 per cent solution of Roccal. The exact amount of cationic detergent used in preparing the dilute solution is not critical.

If we were dealing with a chemically pure substance such as 100 per cent dodecyl benzene sodium sulfonate, it would be a simple matter to prepare and use a dilute cationic detergent solution of some definite and exact normality, for example 0.0020 *N*, and to calculate the results by using molecular weights. But the commercially available alkyl aryl sulfonates are not pure compounds—they are all extremely complex mixtures with variations in alkyl chain length and structure. Hence it is necessary for accurate results that the dilute cationic detergent solution used for the titration be standardized against a known amount of the alkyl aryl sulfonate used in the formulation of the hard water soap undergoing analysis. The organic strength of the alkyl aryl sulfonate must also, of course, be known or determined to permit calculation of the organic sulfonate content of the soap.

To illustrate the use of the method, soaps were prepared in the laboratory; into each one were incorporated known amounts of 30 and 35.25 per cent of a high organic alkyl aryl sulfonate designated Nacconol RB 85. These soaps were then analyzed for their organic sulfonate content by titration with a dilute solution of Hyamine No. 1622, standardized against the Nacconol RB 85 used.

STANDARDIZATION OF CATIONIC DETERGENT SOLUTION

In the procedure for standardizing the cationic detergent solution, the following were used: (*a*) Hyamine No. 1622, 0.75 g per liter, and (*b*) Nacconol RB 85, 0.500 g per liter. Organic sulfonate content of the Nacconol RB 85, determined by standard methods, was 85.6 per cent.

Measure a 25.00-ml aliquot of the dilute organic sulfonate detergent of solution (*b*) into an 8-oz glass-stoppered bottle. Dilute to 100 ml with distilled water, add 50 ml chloroform, 0.25 g anhydrous sodium sulfate, and 0.5 ml bromphenol blue indicator.

From a 25-ml buret, add the dilute cationic detergent solution (*a*), at first in portions of 1 to 2 ml at a time, shaking vigorously after each addition. In the early stages of the titration the chloroform tends to emulsify into the aqueous phase, but as the end point is approached the mixture separates more readily into layers. Allow about ½ to 1 min to elapse between smaller (0.1 ml) additions of the cationic detergent as the end point is approached. The end point is taken as the point at which a blue-green color first appears in the chloroform layer. Holding the 8 oz bottle against a white background will assist in seeing the end point.

Run a blank determination, without the addition of any anionic detergent, to determine the amount of standard cationic solution required to initiate the transfer of the indicator from the aqueous to the chloroform layer.

Calculation: Dilute Hyamine No. 1622 solution required, corrected for blank of 0.07 ml, was 16.17 ml for 25.00

ml aliquot of dilute Nacconol RB 85 solution containing 10.70 mg organic sulfonate. Hence, 1 ml Hyamine No. 1622 solution = 0.662 mg Nacconol RB 85 organic sulfonate.

Preparation of Hard Water Soap

Laboratory batches of framed hard water soap were made by the formulations shown in Table I.

TABLE I.—TEST SOAPS.

	Parts by Weight	
	Soap No. 1	Soap No. 2
Tallow fatty acids	340	387.5
Cocoanut fatty acids	64.5	...
Nacconol RB 85	300	352.5
Carboxymethyl cellulose	10	10
Caustic Soda, pellets	63.5	57.5
Water	206	182.5
Perfume	5	5
Titanox	...	5
	1000.0	1000.0
Calculated moisture, per cent	24.1	21.2
Calculated organic detergent, per ceat	25.68	30.17

Soap No. 1 conforms closely to U.S. Army Specification 22-275 (April 8, 1948) for all-purpose soap which requires a minimum of 25.0 per cent organic detergent, a maximum of 25.0 per cent moisture for the framed type, a minimum of 1 per cent carboxymethyl cellulose, and between 10 and 30 per cent cocoanut oil in the soap stock.

Soap No. 2 made without cocoanut oil is somewhat higher in detergent content and lower in moisture.

Determination of Organic Sulfonate in Hard Water Soap

Prepare a solution, designated solution A, by dissolving 10.00 g of soap (shaved into thin slices or ground and well mixed) in distilled water, and diluting to 1 liter.

Dilute a 100-ml aliquot of solution A to 1 liter with distilled water. This is solution B, containing 1 mg of sample per milliliter

Pipet a 50-ml aliquot of solution B into an 8-oz glass-stoppered bottle. Add 50 ml of chloroform and 0.5 ml bromphenol blue indicator. Then acidulate with 1.0 ml 1 *N* hydrochloric acid, stopper, and shake vigorously to decompose the soap. Add 0.1 *N* caustic soda gradually with vigorous shaking until the color of the solution returns to blue, at a pH of about 5.0. Add 0.25 g anhydrous sodium sulfate and dilute to 100 ml with distilled water. Titrate with standardized cationic detergent solution to the proper end point.

Calculation: Per cent organic sulfonate =

$$\frac{(\text{ml cationic solution minus blank}) \times \text{equivalent mg per ml}}{\text{weight of sample in mg}} \times 100$$

Titration of a known amount of Nacconol RB 85 by this method in the presence of one to ten times its weight of pure soaps showed complete recovery of the Nacconol.

The method was applied to the two soaps made in the laboratory, with the results shown in Table II. The elapsed time required for the analysis is approximately 1 hr per sample.

The results in Table II indicate the accuracy of the method to be 1 per cent or less of the organic sulfonate present, that is, 0.25 per cent or less for a soap containing 25 per cent of organic detergent.

TABLE II.—COMPARISON OF CALCULATED AND EXPERIMENTAL RESULTS ON TWO SOAPS.

	Moisture Content Found at Time of Analysis, per cent	Organic Sulfonate Content		
		Calculated at Time of Analysis, per cent	Found by Titration, per cent	
Soap No. 1	23.42	25.92	26.04 25.85 25.81	Av. 25.90
Soap No. 2	21.50	30.17	30.42 30.51 30.23	Av. 30.39

Application of Method

While the method is perhaps most useful as a control method in the manufacture of soaps containing synthetic detergents, it could also be used for the analysis of samples of hard water or sea water soaps, submitted for qualification tests or taken from deliveries under contracts, provided samples of the detergent or detergents used in production were also submitted along with the formulations.

The Effects of Detergents on Sewage Treatment Processes—A Review

By Raymond Manganelli[1]

With increasing usage and expanding production of detergents (over 1.5 billion lb per year), the ultimate presence of these agents in sewage has drawn attention to their possible influence on treatment processes.

Some phases of a series of laboratory studies are briefly reviewed here; the studies were undertaken to determine and describe some of the principal effects of these agents in concentrations anticipated in sewage (0 to 100 ppm).

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Effect on Sewage Strength and Sedimentation

Replacement of soap by detergents would essentially reduce the strength of sewage. The biological oxygen demand (B.O.D.) of soaps usually ranges between 1 to 1.5 ppm, whereas the B.O.D. of detergents varies from 0 for the Nacconol type to 500,000 ppm for some of the oxidizable fatty alcohol sulfates and nonionic Tween 80 types. A reduction in the range of 15 to 50 ppm of sewage B.O.D. would be realized by replacement of soap by detergents.

Generally, sewage entering a treatment plant is first allowed to settle in order to separate the heavier organic solids which are subsequently stabilized by anaerobic digestion. A study of the effect of household type anionic detergents on sewage sedimentation showed a decrease in removal of suspended solids and an increase in the amount of grease remaining in the effluent. The additional load of pollutional materials would then be projected upon the secondary treatment units.

Effect on Anaerobic Digestion

Examination of the influence of detergents (in concentrations up to 100 ppm) on digestion of primary sludge from the settling units demonstrated no material effect of anionic, nonionic, and

cationic agents on gas production, grease, and volatile matter reduction. The high concentrations (100 ppm) of anionic and cationic types exhibited a slight inhibitory effect on gas evolution. Higher concentrations and accumulation of these agents in a digester may produce a marked suppression of the digestive processes. However, even when detergents have no inhibitory effect on digestion, a decrease in gas production can be anticipated if digestible and gas-producing soap compounds in sewage are replaced by detergents.

Effect on Chemical Coagulation of Sewage

Some treatment plants employ chemical coagulation to enhance the settling of suspended solids and aid in the removal of colloidal particles. This flexible process can achieve purification efficiencies intermediate between plain sedimentation and complete biological treatment. In a study using $FeCl_3$ as coagulant, it was found that the general adverse effects of detergents displayed a similar trend: namely, an increase in effluent turbidity, a decrease in B.O.D. removals, and a lengthening of floc formation time accompanied by lessening of floc size.

Specifically, Nacconol N.R. (anionic detergent) interfered with flocculation and coagulation of sewage in presence of low iron dosage (10 ppm Fe). The dispersive action of Nacconol and its attendant interference with purification were overcome by optimum iron dosage (25 ppm Fe) for raw sewage.

The impairing effect of nonionic Tween 80 on turbidity and B.O.D. removals, sludge accumulation, and floc formation persisted even when optimum dosage of coagulant was employed. This action could not be alleviated by a very high dosage (50 ppm Fe) of iron salt.

Cationic Ceepryn induced an increase in turbidity upon addition to sewage. An increased removal of turbidity was obtained with subminimal iron dosages in the presence of Ceepryn. A higher degree of purification upon the addition of the cationic detergent was evident in an increase of sludge volume produced, as well as in B.O.D. removals.

Despite the varying degrees of influence of different and specific detergents, chemical coagulation of sewage remains a feasible and practicable method for treatment of sewage containing detergents.

Effect on Activated Sludge

In certain treatment plants, a high degree of purification may be required for sewage. In addition to primary units, secondary or biological treatment such as the activated sludge process is necessary. This process makes use of biological communities that in the presence of oxygen produce rapid clarification of sewage and oxidation of organic materials. A series of experiments was conducted to determine the effect of the three main types of detergents in a range of concentrations expected in sewage on the activated sludge process with respect to (*a*) repeated additions on oxidation of sewage, (*b*) interacted detergents on oxidation of sewage, and (*c*) repeated additions on nitrification capacity of activated sludge.

The effect of repeated additions of detergent on biological purification by activated sludge, based on B.O.D. removals and final turbidity of the effluents, was studied. It was found that repeated passages of surface-active agents of the Tween 80 type, which are nonionic in character and biologically oxidizable, have no effect on activated sludge itself or on its purification capacity. Repeated additions of high concentrations (100 ppm) of anionic Nacconol and cationic Ceepryn caused rapid deterioration of the sludge and its oxidizing ability. The effect was more pronounced with the cationic detergent. Low concentrations of these agents, when present continuously, induce comparable results.

It is known that interaction of most cationic and anionic detergents causes formation of an insoluble complex that precipitates or remains in suspension, depending on the presence of excess quantities of either reactant. To determine whether the product of such an interaction was inhibitive to sewage oxidation by activated sludge organisms, anionic Nacconol and cationic Ceepryn were mixed with sewage and activated sludge in equivalent concentrations of 0, 25, 50, and 100 ppm so that the total quantity of detergent present would be 100 ppm. Additions of the Nacconol and Ceepryn combinations resulted in diminished retardation of oxidation in 6 hr. The retardation was overcome in 24 hr when Nacconol concentrations were equal to or greater than the amounts of Ceepryn present.

In a second series of experiments, 25 to 100 ppm of Nacconol were added to 100 ppm Ceepryn. The results showed that as the concentration of Nacconol added to the cationic agent decreased, the determent of oxidative activity of the sludge organisms became more pronounced.

Detergent complexes are the form in which these agents would probably exist under field conditions. It is significant, therefore, that interaction of anionic and cationic types decreases the inhibitory action of each detergent. Also the concentration of the unreacted agent is more important than the total concentration of detergents present.

Effect on Nitrification Capacity

Nitrification in the activated sludge process serves as a yardstick designating the progress of decomposition and the degree of oxidation of pollutional matter. Organic nitrogenous compounds are broken down biologically to ammonia, which is then oxidized by specific autotrophic bacteria in two distinct steps: first to nitrites and subsequently to nitrates. Activated sludge usually contains an ample population of nitrifying organisms capable of carrying out these reactions rapidly.

Experiments were conducted to determine the effect of repeated additions of detergents on the nitrifying organisms and consequently on the nitrification capacity of activated sludge. Nacconol, Ceepryn, and Tween 80 in various concentrations of 10 to 100 ppm were added twice daily to activated sludge (1000 ppm) and sewage mixtures for 7 days (13 passages). The samples were aerated by continuous mechanical shaking at 20 C to insure adequate oxygen diffusion which because of excessive foaming would be impossible by compressed air bubbling.

It was found that additions of nonionic Tween 80 exhibited no effect on the ammonification and nitrification processes. Repeated additions of anionic Nacconol first retard the activity of the nitrite oxidizers, yielding an increase in nitrite concentration, then curb the activity of the ammonia oxidizers, and finally interfere with ammonification. Cationic Ceepryn affects the ammonia oxidizers at the same time as the nitrite oxidizers. Further additions of this agent have a detrimental effect on the ammonifying organisms.

Under laboratory conditions, the detrimental action of Nacconol and Ceepryn is observed within a relatively short time. Suppression of the nitrite oxidizing organisms occurred within 48 hr (3 passages) for all concentrations (10 to 100 ppm) of Nacconol and Ceepryn; while complete inhibition of the nitrite oxidizers was evident in 5 days (9th passage) or less for all concentrations of both ionic agents with exception of 10-ppm Nacconol additions which showed continued retardation through 7 days. In the main, the effects of cationic Ceepryn were more marked.

In general, the oxidative ability of the sludge organisms was diminished and the community of organisms and the character of biological floc were impaired by repeated additions, for 1 week, of Nacconol and Ceepryn type detergents in concentrations of 10 to 100 ppm.

Under field conditions, factors such as continuous flow process, wasting of sludge, sludge age, concentrations, and variable discharge of detergents will influence the extent of the effect on the activated sludge process.

In a series of laboratory activated sludge experiments using diffuser type aeration, problems such as foaming, carryover of floc, and floc agglomeration were encountered. Such difficulties are now in evidence in many activated sludge plants throughout the country.

Effect on Chlorination

The effluent from the sedimentation tank of a primary treatment plant or from a final clarifier of a secondary treatment unit is usually chlorinated before being discharged into the receiving stream. Consequently, a study was undertaken to determine the effect of detergents on the chlorination of sewage. It was found that anionic Nacconol and nonionic Tween, in quantities expected in sewage, had no beneficial action on the bactericidal efficiency of chlorine in sewage. The cationic Ceepryn caused a considerable decrease in numbers of coliform organisms in the effluent and contributed to sewage chlorination.

Summary

Increased production and use of detergents have, in recent years, drawn considerable attention to the possible effects of these agents on sewage treatment processes.

The action of detergents depends on the concentration and type present in sewage. In general, replacement of soap by detergents will reduce the strength of sewage. Settling devices may be affected, producing a poorer effluent and projecting an increased load to the secondary units.

Gas yields from anaerobic digestion may be diminished without inhibition or retardation of the digestive processes.

Anionic and nonionic detergents interfere with chemical coagulation of sewage in terms of purification attained and modification of the floc formed, but an increase in dosage of coagulant can alleviate some of these adverse effects.

Repeated additions of Nacconol and Ceepryn cause a decrease in oxidizing, purifying, and nitrifying capacities of activated sludge accompanied by a general deterioration of its physical and biological properties. Oxidizable Tween 80 induces no detrimental action on activated sludge or its activities.

Interaction of anionic and cationic detergents tends to diminish the inhibitive action of these agents on oxidation by the activated sludge organisms.

The cationic detergent produces an added effect on the bactericidal activity of chlorine, whereas the anionic and nonionic types exhibit no measurable beneficial effect.

Asphalt Tile Cleaner Specifications

By A. C. Zettlemoyer[1]

Asphalt tile is used widely in public buildings and offices, in apartments and housing developments, and in kitchens, bathrooms, and playrooms in the home. Where severe grease and oil conditions exist—such as in animal hospitals, automobile showrooms, beauty salons, butcher shops, institutional and restaurant kitchens, gas station offices, printing shops, etc.—grease resistant asphalt tile is used. About 16,000 acres or about 650 million sq ft of asphalt tile were installed last year.

Specifications for asphalt tile cleaner were developed by the Technical Research Committee of the Asphalt Tile Institute (ATI) for use by the industry. Many of the complaints about installations of asphalt tile are really due to improper maintenance of the tile. As a result there had arisen the need for asphalt tile cleaner specifications.

The Asphalt Tile Institute encompasses practically all of the companies manufacturing this product in the United States. The Technical Research Committee is responsible for developing product specifications and specifications for auxiliaries used in the installation and maintenance of asphalt tile. This committee cooperates with state and federal organizations in developing their specifications and often initiates such specifications when no interest has yet developed on the part of the government organizations.

In 1946, the Floor Protection Committee of the ATI asked the Technical Research Committee for recommendations on specifications for cleaners. Often when such requests are made, new test methods must be worked out by cooperative efforts in the laboratories of the members. The mode of operation is similar to that of ASTM committees. Progress is made by round-robin testing and, although it is sometimes slow, this progress is generally in the form of sensible conclusions.

At the outset it was recognized that the primary problem would be to develop a suitable test method for measuring the effect of cleaners on tile. This problem was to be the chief stumbling block.

A review of the nature of asphalt tile will be given first in this paper to show how the ingredients and nature of the finished product influence the nature of the specifications to follow. The history and source of other specifications and test methods incorporated in three ATI cleaning specifications will then be described. Following this, an ATI specification for soap-type cleaners will be discussed as a basis for the test method development. Next, the main topic, a summary of the history of the development of this test method, will be presented. Finally, ATI specifications for nonsoap-type cleaners and for synthetic detergent-type cleaners, both for use on asphalt tile floors, will be discussed on the basis of the soap-type specifications.

Nature of Asphalt Tile

The term "asphalt tile" is somewhat of a misnomer. Only in the darker shades are asphaltic type materials or gilsonite used. Usually the binders, which are of primary concern here, are based on coumarone-indene resins derived from coal tar or on petroleum resins having similar physical properties. These resins generally have very few functional groups of any kind; they have surprisingly low molecular weights and are highly condensed ring structures which yield softening points of the order of 100 C. The plasticizers included in the tile formulation are usually pitches based on vegetable, animal, tall oil, etc., or hydrocarbon oils of one kind or another. The binder makes up only about one quarter of the total composition of the tile. Except for a few per cent of pigments, the largest portion of the tile is filler composed mainly of short fiber asbestos with minor amounts of other minerals such as talc and carbonates.

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] Lehigh University, Bethlehem, Pa.; and Kentile, Inc., representative on the Technical Research Committee of the Asphalt Tile Institute.

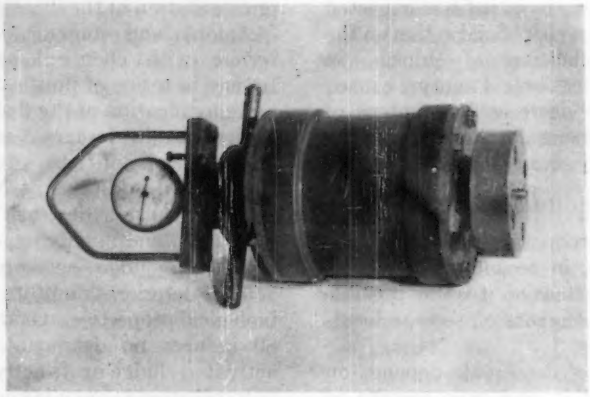


Fig. 1.—McBurney Indentation Tester.

Special grease-resistant resins and plasticizers in a variety of types are used to manufacture grease-resistant tile. There are two classes of these tiles covered by an interim Federal Specification, SS-T-307. Class 1 is a tile resistant to edible oil and alkali, and Class 2 is a tile resistant to mineral oil and alkali. These tiles are sometimes more readily attacked by alkali and by cleaners than is regular asphalt tile.

The basic specification in asphalt tile manufacturing is the one developed by the Government with the cooperation of the Asphalt Tile Institute and modified several times over the past twenty years. This Federal Specification SS-T-306b, besides dimensional and appearance requirements, covers indentation, impact, deflection, and curl. The curl test of the specification is performed on limestone slabs partially immersed in water. Asphalt tile has been specifically developed to meet the alkaline conditions produced by ground water and concrete which are not similar to those produced by surface-active agents. In the presence of such agents, alkali attacks tile much more readily. Therefore, the tile–cleaners problem is different and more severe than the tile–concrete problem.

The indentation test in the specification SS-T-306b is of importance to our discussion also. In it, the McBurney identation tester[2] is used (see Fig. 1). The tester consists essentially of a rod with a hemispherical end $\frac{1}{4}$ in. in diameter, through which an initial load of 2 lb and a final total of 30 lb can be applied to the surface of the tile, and a dial gage from which the indentation can be read. Strict requirements have been specified for the indentation at 1 min and at 10 min at 77 F and at the end of 30 sec when tested at 115 F. This most basic test of the industry guards against excessive cold flow and gives practical indications of many other properties. At one time it was thought that this tester might be used to measure the effect of cleaners on tile. This will be referred to a little later.

[2] J. W. McBurney, "Indentation of Asphalt Tile," *Proceedings*, Am. Soc. Testing Mats., Vol. 34, Part II, p. 591 (1934).

ATI Specification for Soap-Type Cleaners

The most recent revision of the ATI specification for soap-type cleaners, dated January 20, 1953, is a slight modification of the original specification dated February 16, 1951. The cleaners covered by the specification are almost entirely of the potash soap type, either in liquid or paste form. According to it, "They shall contain no solvents, oils, or other materials that have an injurious effect on asphalt tile." The specification's eleven detailed requirements include soap content, hydrogen ion concentration, free alkali, free ammonia, free oil, solubility, odor, conditioning in container, stability in storage, rinsing properties, and deleterious action on tile; they are summarized in Table I.

Except for the test method for measuring the deleterious action on tile, most of the methods included and their requirements were derived from specifications of the Rubber Manufacturers' Assn., the Armstrong Cork Co., the Johns-Manville Corp., and two Federal Specifications [P-C-431 (April 17, 1947), Cleaner for Painted Surfaces Containing Synthetic Detergent, and P-S-536a (June 25, 1942), General Specifications and Methods for Sampling and Testing Soap and Soap Products]. Each of the eleven requirements of the ATI specification were studied, as were possible test methods.

The Anhydrous Soap Content of the cleaner shall be a minimum of 20 per cent for liquid and 43 per cent for paste soap by weight calculated as potash soap. The method of its analysis which has been developed is a slight modification of the one given in P-S-536a; it is based on the separation of fatty acids with sulfuric acid.

The pH of a 1 per cent solution of the cleaner, according to the specification, shall not be less than 8.5 nor more than 11.6 when tested with a glass electrode. The ATI method for testing the pH is based on P-C-431.

The Free Alkali requirement is that it shall not exceed 0.1 per cent when titrated with acid using phenolphthalein. This allowable percentage does not include the ammonia concentration which is subtracted from the total titration. Because of the nature of asphalt tile, this requirement is important since alkali together with soaps or other surface-active agents can produce, as indicated earlier, severe attack.

Free Ammonia is determined separately. The analysis is based on distillation from a Kjeldahl flask into acid, which is back-titrated with standard alkali using methyl red as an indicator. The total amount shall not exceed 0.5 per cent by weight and is determined from the solution at the maximum concentration recommended for use. This requirement and method were first derived from the specification of the Rubber Manufacturers' Assn. (RMA). Ammonia is not very harmful to asphalt tile because it usually volatilizes before it can do serious damage.

Free Oil will attack the binder because most of the resins used have some solubility in oils. The requirement of the RMA was followed in limiting the total free oil to 1 per cent by weight. The analysis is based on extraction with

TABLE I.—REQUIREMENTS OF THE ATI SPECIFICATIONS FOR CLEANERS.

	Soap	Non-Soap	Synthetic Detergent
Soap content, per cent	{ Liquid 20 { Paste 43	None	None
pH	8.5 to 11.6	8.5 to 11.6	5.5 to 10.0
Free or total alkali, per cent	0.1 (free)	16 to 19 (total)	...
Free ammonia, per cent	0.5	0.5	...
Free oil, per cent	1.0	...	...
Solubility	Complete	Complete	Complete
Odor	Not offensive	Not offensive	Not offensive
Condensate in container	No change	No change	No change
Stability in storage	Stable	Stable	Stable
Rinsing properties	No deposits	No deposits	No deposits
Deleterious action (scratch width increase), per cent	40 No bleeding	40 No bleeding	40 No bleeding
Volatile matter, per cent	...	10	...
Organic matter, per cent	...	None	...

petroleum ether. Again, the RMA specification was the source.

Solubility in distilled water "shall be complete" as suggested by P-C-431. This requirement is included to avoid mineral abrasives and is based on a similar one in P-C-431.

The Odor, Conditioning in Container, and Stability in Storage Requirements seem impossible to define precisely at present. "The cleaner shall be free from offensive odors." The other two requirements are mainly to cover gelling in container and loss of effectiveness.

The Rinsing Properties Requirement is that the cleaner "shall be free-rinsing." Some cleaners deposit a white sediment on tile which is quite objectionable. (If the cleaner builds up on the tile and remains there for some time, the attack can become serious.)

Deleterious Action on Tile concerns softening and discoloration of tile. As far as discoloration is concerned, the cleaner must not cause the tile colors to bleed. Upon application of the cleaner to the tile, there should be no tendency to remove the color or to spread the color from one tile to another. The tile is inspected after rinsing and drying to make sure that it shows no objectionable change in color.

The Attack of Reagents on Asphalt Tile

The history of the development of a satisfactory test for measuring the softening action of various ingredients on tile has been long and difficult. Although it should be realized that the final pages have probably not been written, after many attempts, a limit method has been finally accepted by all of the members of the ATI. The method is based on the Taber shear-hardness tester, and cleaners are found to be acceptable if they do not increase the scratch width by more than 40 per cent when tested in a manner to be described later. A number of other methods were tried before the Taber test was finally accepted.

Determining the effect of a reagent on a smooth-surface flooring is a difficult matter, because of (*a*) the inhomogeneity of such surfaces and (*b*) the "attack by attrition" which often occurs.

Because the asphalt tile ingredients are put together by mixing in Banbury mixers, two-roll, or similar mills, somewhat inhomogeneous mixes result in so far as fine scale properties are concerned. Furthermore, the calendering operations are not perfectly successful in knitting together the surface of the tile. Today's practice in such situations is to set up test methods based on statistical analysis and such analysis shows that the single measurements commonly made in routine control may be unreliable. Inherent in the statistical method is the difficulty of evaluating quickly the attack on the tile.

In numerous cases, it has been found that the attack of reagents by attrition on the tile is only skin deep in laboratory tests. Indeed, it has required a rather close look at the tile under test in order to learn that any appreciable attack has occurred. Nevertheless, in practice, the reagents often cause the tile to deteriorate rather rapidly. This lack of correlation can be explained on the basis that, when installed, the surface attack is tracked away on the shoes of people walking over the floor. Then fresh surface is continually exposed and so the attack goes on until it reaches considerable proportions and the tile becomes pock-marked, unsightly, or even disintegrated.

For these reasons a fingernail test has been developed which represents a high degree of skill in the art of asphalt tile manufacture. As in many fields of other materials, the expert examiner of asphalt tile can rate the attack with his fingernail as well as by any test that has yet been developed. Indeed, it seems doubtful that his test will be bettered in the foreseeable future. But, although this test is used widely and successfully in the industry, it could not be used as a basis for the ATI approach. It could hardly have been possible to make an expert out of each tile tester who would use such specifications. The ATI has been forced, therefore, to look for a more quantitative method.

Early in the test's development several companies examined various existing methods of test. The McBurney indentation tester and the flexure tester were both used during this period. Certainly, if the attack is rapid and penetrates throughout the tile, these tests will give some indication of the deleterious action to be expected in practice. But, in cases where only the skin is affected by the attack, the indentation and flexure test results change only very slightly. Such tests are insensitive and do not detect fine differences in homogeneity. While it is true that the *very* fine differences in homogeneity need not be uncovered, it is also true that the fine differences that may be significant have not been revealed by these tests.

Because surface layer attack of tile would wear this surface away more readily several abrasion tests were also studied. The Taber abraser has an action that simulates treading with a foot on a floor. The abrasion wheels move in a vertical plane and the sample to be abraded revolves in a horizontal plane. Duplicate abrasion wheels did not produce duplicate abrading properties. Also, the surface of the wheel became clogged with the plastic binder material. Unfortunately, this clogging effect seemed to be different for each tile formulation, suggesting that a change in the formulation affects the way in which the clogging occurs. It was not sensible to adopt a standard number of cycles of revolution for the test, because the depth of attack is not the only criterion of how serious the attack may be in practical installations.

The Armstrong abrasion tester, still under development, uses rolls of sand paper so that a new surface of the paper always contacts the tile as the samples revolve. A zinc plate is tested in series with the tile samples to standardize the paper. This method (which will probably be costly to operate) has been used with some success.

During 1946, under the Kentile Fellowship at Lehigh University, one of the Fellowship's tasks was to develop a mechanical test for grease resistance of asphalt tile. There were inherent difficulties in developing a pertinent test. Also, the value of the simple, fingernail test was appreciated. The Taber shear-hardness attachment for the Taber abraser was available and it was recognized that the test in which this was used had some of the charac-

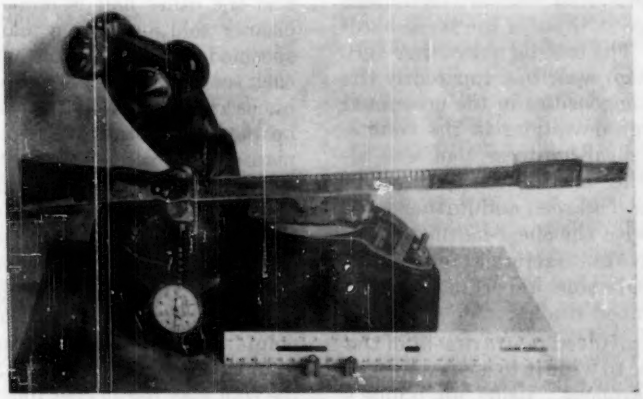


Fig. 2.—Taber Abraser with Shear-Hardness Attachment.

teristics sought (see Fig. 2). The S-20 precision radius tool on this instrument is mounted on the underside of a scale beam in line with the specimen holder and is provided with a tungsten carbide edge, precision ground to a 25-mm radius. The radius tool cuts a shallow groove, varying in width according to the load applied and the resistance of the material to the shearing action. The groove width developed by this tool is sensitive merely to the nature of the top surface of the sample.

In January, 1947, Kentile, Inc., presented to the ATI Technical Research Committee initial information on a grease-resistance test using the Taber shear-hardness attachment. Fairly good results in a single laboratory with a single operation had been obtained. But when the test was tried in round-robin studies in other laboratories, standard deviations of 10 to more than 25 per cent were often encountered. With improvements in technique and limit requirements, the Taber shear-hardness test was finally adopted in the Government specifications for grease-resistant asphalt tile (SS-T-307) and for vinyl plastic floor tile (L-T-751). Apparently, the National Bureau of Standards now classifies this test as being somewhat more stringent and sensitive than many other tests included in Federal Specifications.

Also, during development of the scuff test, the Johns-Manville Corp. introduced a modification which used a ball bearing mounted in a Tiffany setting. This device could be set in the beam scale in a similar manner to that for the shear tool and with it the so-called rolling ball hardness test could be made. The tile revolving under the ball develops an annular groove whose width depends upon how much the tile has been affected by the reagent. The ball was introduced in place of the tool to circumvent the large amount of wear which such a tool encounters in scratching a plastic material, especially when it is filled with a large amount of filler. This test produced standard deviations just as large as those of the shear-hardness tool. The ball did not change very much through wear but apparently the small inhomogeneities in tile accounted for the large deviations in the results. Since the shear-hardness tool was already on the market, the rolling ball method was discarded and further work was done with the shear-hardness tool.

Four important factors were found to be of considerable importance during these continued studies.

The first involved pretreatment of the tool in order to wear it to a constant degree of sharpness. Using an unfilled plastic reference plate, it was found that the width of the scratch on the reference plate fell drastically after scratching asphalt tile with the tool. For example, in testing a given tool, a scratch 1 in. long was made on the reference plate with a 1000-g load on the beam, and then a scratch was made on a piece of asphalt tile for one revolution with 500-g on the beam. On the reference plate a new test scratch was made, and so on alternately, thus predulling the tool. It was found that after five such scratches on tile the reference width in mils had fallen from the order of 140 to 40 and would remain constant for a considerable time thereafter. The scratch width on dry tile would be approximately 50 mils, varying somewhat with the nature of the tile.

A second factor was the effect of temperature. The test was found to be quite sensitive to temperature. For example, alkali tests run in 5 per cent sodium hydroxide for 3 hr gave considerable increase in scratch widths with temperature rise. In one series of tests the increase amounted to about 5 per cent per degree Fahrenheit.

Third, it was discovered that immersion of the tiles in the cleaning solution must be done so that solution can reach all of the individual tiles and so that circulation will not be impeded. In one round-robin series of tests it was found that a complete lack of correlation could be accounted for by the fact that some laboratories had simply set the tiles in the cleaner solution, one on top of the other. Present specifications call for separation of the individual tiles and stirring.

A fourth factor to which the test was sensitive was the softening of the tile merely by immersion in distilled water. Tests indicated that this softening often amounted to anywhere from 10 to 15 per cent and varied somewhat with the source of the tile.

In order to keep the effect of the lack of homogeneity to a minimum, the test was developed so that one half of each 4-sq in. piece of tile is immersed in water and the other half is immersed in the cleaner solution at the manufacturer's specified maximum concentration for each set of tests. Five sets of such specimens are taken so that the average will be more representative of the over-all picture. Immersion is for 24 hr; each set is then removed from the solution, blotted with paper towel, and tested on the Taber abraser, making a 3-in. long scratch on each specimen under a load of 500 g. The width of each scratch is measured to within 0.001 in. at three points; measurements are made away from the first part of the scratch when the tool may dig deeper due to starting conditions.

It should be emphasized again that each scratch tool must be predulled so that it produces a scratch on tile before immersion of 0.050 ±0.005 in. Furthermore, the scratch on the fresh tile should be a mere polishing action and should not shave the tile surface; an occasional tool will not operate properly and so must be predulled further.

The per cent increase is calculated in each set based on the width of the scratch of the water-immersed sample. If the average increase falls above 40 per cent, the material is considered to have failed the test. However, if it is below 50 per cent, two more sets of tests are run and the average of all three tests taken. If the test ranges between 30 and 40 per cent the examiner may reserve the right to retest the tile. (Indeed, as written into the test now, the range between 30 and 50 per cent is a doubtful range, requiring retest.)

In Table II a summary of a round-robin study is presented as conducted by the Technical Committee after these improvements had been incorporated. Notice that very few failures are found even though ordinary soap is often rather harmful to tile. It should be emphasized that a 5 per cent difference in this test with two cleaners does not mean that the one is 5 per cent better than the other. The low results with this particular inorganic cleaner do appear to be significant.

TABLE II.—SUMMARY OF THE ATI SCUFF TEST ON CLEANERS.

	Scratch Width Increase, per cent		
	Household Soap	Inorganic	Synthetic Detergent
Light Tile			
Laboratory A	47.5	20	27
B	26	5	31
C	35	16	38
D	36.5	5	41
Average	33.8	15.3	34.3
Dark Tile			
Laboratory A	32	23	42
B	27	7	27
C	23	9	21
D	35	2	34
Average	29.3	10.3	31

Specifications for Nonsoap-Type Cleaners

This specification follows the soap-type cleaner specification closely. A primary difference is that the specification includes a test to determine the absence of "true" soap (the technical definition) by testing for a layer of fatty acids formed when a solution of the cleaner is acidified with sulfuric acid and heated. Also, the total alkalinity calculated as Na_2O must not be less than 16 per cent nor more than 19 per cent when titrated with 0.5 *N* sulfuric acid.

In other respects this specification follows the first one.

Specifications for Synthetic Detergent-Type Cleaners

An important difference here is that the pH value is restricted to a different range, 5.5 to 10.0 (similar to the requirement in P-C-431). This requirement has been used because it has been found that such cleaners generally fall within this class. It has furthermore been found that high alkalinity of such cleaners is rather dangerous because the alkalinity coupled with the wetting action of these synthetic detergents tends to disintegrate tile rather rapidly; the effect is often quite similar to that caused by alkaline soaps.

Summary

These three cleaner specifications represent a point of view which is different from the usual one taken by the Asphalt Tile Institute. Whenever possible, the ATI desires to write specifications based on performance rather than on composition. But in this case we at the Institute simply do not know of an acceptable cleaning test that can be used to examine the efficiency of cleaners for asphalt tile. When and if such a test is developed, specifications could be based on it and on a test for the possible deleterious action of cleaners on tile.

Acknowledgment:

The author wishes to acknowledge the assistance of C. B. Whittelsey, Jr., Managing Director of the ATI, and Charles E. Dill, the Flintkote Co., for aid in assembling the information for this paper.

Detergents in Drycleaning

By G. P. Fulton,[1] J. C. Alexander,[1] A. C. Lloyd[1], and M. Schwartz[1]

When garments are drycleaned in an organic solvent containing no detergent, the drycleaning process removes much soil of a greasy nature and also removes some insoluble soil. Drycleaning without a detergent does not remove much water-soluble soil from fabrics. By water-soluble soil we refer to materials such as salt and various sugars that are contained in many foodstuffs, drinks, and perspiration. Spots from water-soluble soil are usually removed from garments by a separate operation after the drycleaning process. This operation is known as "spotting." Spotting involves the application of water or a mixture of water and various chemicals to local areas of a garment to remove water-soluble spots. Since each garment—and in fact each spot—must be treated individually, spotting is a rather costly process.

When a garment contains an unusually large amount of ground-in insoluble soil or is stained with quite a few water-soluble spots, the drycleaner must wet-clean it to restore it to a usable condition. Wet-cleaning is a water-cleansing process involving lukewarm water and a neutral soap or synthetic detergent. With many fabrics it must be a hand process. It is carried out in addition to the normal drycleaning operation. Moreover wet-cleaned garments require more time for pressing. Thus the wet-cleaning of a garment involves considerable extra expense.

Usually when a drycleaner uses a detergent in his drycleaning solvent he hopes to achieve several ends:

1. By increasing soil removal and whiteness retention he hopes to give back to his customer a clearer, brighter garment.
2. He hopes the drycleaning detergent removes some water-soluble spots, and thus decreases somewhat the amount of spotting necessary after drycleaning.
3. He hopes that the detergent will decrease, at least to some extent, the percentage of garments that require wet-cleaning.

For these reasons any drycleaning process that reduces spotting and wet-cleaning will be received with considerable enthusiasm in the trade.

Early Attempts to Evaluate Drycleaning

The National Institute of Drycleaning (NID), at Silver Spring, Md., includes a commercial drycleaning plant called the Institute cleaning plant. Some years ago a research project was organized to investigate the correlation of results as shown by test swatches with actual results in the Institute Cleaning Plant. Each test load that was drycleaned contained test swatches to show a number of things:

1. Removal of insoluble soil. For this swatches of acetate—and sometimes also of rayon—soiled with a mixture of carbon and grease were used.
2. Whiteness retention. With each load were included white swatches of rayon, acetate, and wool. Reflectometer readings were made before and after drycleaning to determine whiteness retention.
3. Removal of water-soluble soil. To show the degree of removal of water-soluble soil may seem a strange measurement to those accustomed to working in aqueous systems, since in an aqueous system water-soluble soil is quickly dissolved and removed from fabrics. However, since much spotting and wet-cleaning is done to remove water-soluble soil, it was felt that some swatches containing water-soluble soil should be included. These are called salt swatches and are made by passing a strip of rayon through a 1.5 *N* aqueous solution of sodium chloride. After passing through the salt solution the strip passes through a wringer to remove excess solution, and then is dried by passing over infrared lamps. The strip of fabric is then cut into 4- by 4-in. swatches that are used for the test work. Some of these are analyzed immediately to determine their salt content; others are drycleaned and then analyzed after drycleaning to determine the percentage of salt removed. Sodium chloride was selected as a typical water-soluble soil since it is present in perspiration and in many foodstuffs. Moreover it is easily

NOTE.—DISCUSSION OF THIS PAPER IS INVITED, either for publication or for the attention of the author. Address all communications to ASTM Headquarters, 1916 Race St., Philadelphia 3, Pa.

[1] National Institute of Drycleaning (formerly National Institute of Cleaning and Dyeing), Silver Spring, Md.

determined by analysis. The method of salt analysis used is both quick and simple. The swatch is placed in an Erlenmeyer flask and covered with about 50 ml of distilled water. A few drops of the sodium salt of fluorescein is added as an indicator. It is then titrated with 0.2 *N* silver nitrate. The presence of the cloth in the flask does not interfere with the end point.

Each load for the drycleaning tests consisted of dresses from the Institute cleaning plant and an experimental garment to which was attached our test swatches. The garments and test swatches were hung for several hours in a cabinet and conditioned at constant temperature and relative humidity. The garments and test swatches were then drycleaned. After drycleaning, the load went to the spotter who recorded the total number of garments, the number of garments that required no spotting at all (a figure known in the trade as "pass-ups"), and the number that required wet-cleaning. He also recorded whether he considered the load bright, clear, and easy to spot, or whether he considered it rather dingy and hard to spot.

For the better part of three years, approximately one such test load was run each day. The results were very discouraging. A correlation was not obtained between removal of insoluble soil and plant results. We did obtain some correlation with whiteness retention. This was true to the extent that if the laboratory swatches indicated poor whiteness retention, the spotter also found the load to be poor. The reason for this lack of correlation was probably that the methods of drycleaning used at that time in our tests removed very little water-soluble soil.

Drycleaning Methods Used in the Trade

At this point perhaps it would be appropriate to describe briefly how drycleaning is done. The garments to be drycleaned are agitated in a washer containing a drycleaning solvent. The washer is piped so that solvent can flow out of the washer, through a small tank containing a strainer called a "button trap," through a pump, through a filter, and finally back again into the washer. The method of drycleaning most popular a few years ago was as follows: The solvent at the start of the operation was substantially free of soap or detergent. The garments were first agitated in the washer containing the solvent, without the filter pump running, and a drycleaning detergent was added. After the washer had run for some time, the filter pump was started to circulate the solvent through the filter and to remove soil and some of the detergent. This method, sometimes called the fresh-soap-to-each-batch system, was used rather widely in both petroleum and synthetic solvent systems. It is the method that was used at the Institute in the attempt to correlate test swatches and plant results.

Often an emulsion of water was added to the solvent along with the drycleaning detergent. Such emulsions were usually of the water-in-oil type and made a cloudy mixture in the solvent. Work by A. R. Martin several years ago[2] showed that water thus added in a water-in-oil emulsion was practically all picked up by the garments within a few minutes. The work also showed that the moisture was distributed between the textile fibers silk, wool, rayon, acetate, cotton, and nylon in the same ratio as when these fibers pick up moisture from the air.

For the past few years there has been quite a trend in the industry toward cleaning in what is called a "charged system." In this system of cleaning the solvent in both the washer and filter is charged with a synthetic detergent, usually at a concentration of anywhere from ½ to 1 per cent by volume. The detergent used is soluble in the solvent so it is not removed by filtration. Being a synthetic detergent, it is not hydrolyzed into fatty acid by contacts with garments, as would be a true soap.[3] In a charged system there is usually more detergent present in the solvent than was used in the fresh-soap-to-each-batch system. Although the charged system has been widely used only in the past few years, the system is not new and has been used by some companies for many years.

A still more recent trend in the industry is the use of a charged system containing a higher concentration of detergent, such as 3 or 4 per cent by volume. With such a high concentration of detergent in the solvent, the garments must be given a separate rinse after the washing cycle to remove the detergent from them. Thus the higher concentration of detergent necessitates a two-bath process, which in turn requires some complications in equipment.

In the summer of 1951, the Institute installed such a 4 per cent charged system in one of its laboratory cleaning units. The unit was one employing Stoddard solvent. For over a month test loads were cleaned in this 4 per cent system and several things were observed that had never been seen before at the Institute.

1. It was found that considerable moisture remained in the solvent and was not picked up by the garments. The amount of moisture usually varied from 0.2 to 0.25 g of water per 100 ml of solvent. This moisture did not make the solvent cloudy.
2. The 4 per cent detergent solution removed more salt from our salt swatches than had any drycleaning process previously used at the Institute.
3. Personnel of the Institute cleaning plant stated that little spotting or wet-cleaning was necessary on garments cleaned in the laboratory 4 per cent system.
4. From previous experience, moisture added to a drycleaning system had often caused wrinkling of garments, pilling up of soft textured wools, and shrinkage of some materials. But when using the 4 per cent system, no detrimental effects from added water were noticed.

[2] *Bulletin Service*, Nat. Inst. Cleaning and Dyeing, No. T-268, October 29, 1951.
[3] *Bulletin Service*, Nat. Inst. Cleaning and Dyeing, No. T-242, September 25, 1950.

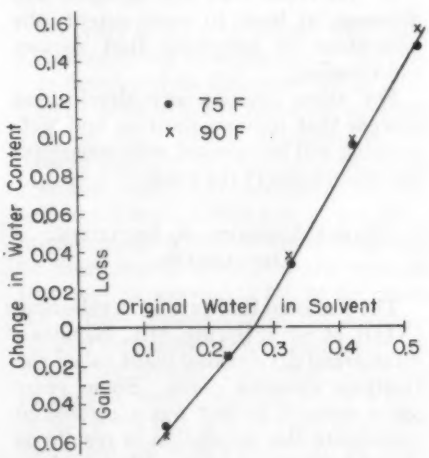


Fig. 1.—Change in Moisture Content of Wool, Preconditioned at 70 Per Cent Relative Humidity and 75 F., When Immersed in Solvent Containing Various Amounts of Water.

Moisture Absorption From the Solvent

At the Institute it was felt this drycleaning system needed investigation since there was a possibility that an equilibrium existed between the moisture in textiles emersed in the solution and the vapor pressure of water in the solution. Some studies were made accordingly. Unfortunately, the results are based on work with trade products rather than pure products.

The first step was to determine how much water textiles gain from a 4 per cent solution of detergent in Stoddard solvent. A trade product was used that has previously been employed in the 4 per cent drycleaning system. It shall be referred to as product A.

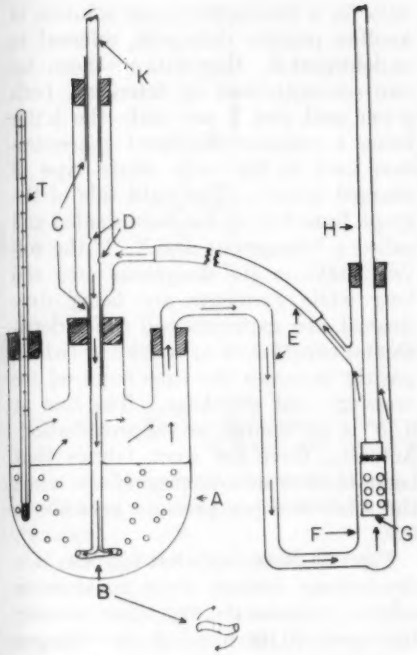


Fig. 2.—Apparatus for Determining the Relative Vapor Pressure of Water in Drycleaning Solvent.

A = Flask containing solvent.
B = Rotating impeller.
C = Oil-sealed bearings.
D = Intake holes in hollow impeller shaft.
E = Connecting tubes between flask and element chamber.
F = Sensing element chamber.
G = Sensing element.
H = Leads from sensing element to controller.
K = Impeller shaft connected to air motor.
T = Thermometer.

Several swatches of wool, each weighing approximately 18 g were conditioned in air at 70 per cent relative humidity and 75 F. A number of Stoddard solvent solutions were then prepared, all containing 4 per cent by volume of the detergent but each varying in moisture content. Of each solution 300 ml were placed in a separate, glass-stoppered flask along with a swatch of the conditioned wool. The flasks were allowed to stand for several hours with intermittent agitation, after which samples of the solutions were removed and their moisture content determined. All determinations of moisture referred to in this paper were made by the Karl Fischer method.[4]

Results are shown in Fig. 1 where the original moisture content of the solution is the abscissa and the gain or loss in moisture of the solution is the ordinate. Obviously the point at which the curve intersects the horizontal line is the moisture content of the solvent in equilibrium with wool, previously conditioned at 70 per cent relative humidity and 75 F

[4] Albert R. Martin and A. C. Lloyd, "Simplified Procedure for Water Determination by the Karl Fischer Method," *Journal*, Am. Oil Chemists Soc. (accepted for publication July 9, 1953).

This experiment was repeated using wool (1) conditioned at 31 per cent relative humidity and 75 F and (2) conditioned at 50 per cent relative humidity and 75 F. Results are shown in Table I.

TABLE I.—EFFECT OF CONDITIONING RELATIVE HUMIDITY ON MOISTURE CONTENT OF SOLVENT IN EQUILIBRIUM WITH WOOL.

Using 4 Per Cent Detergent A in Stoddard Solvent.

Relative Humidity, per cent	Moisture Content, g per 100 ml
31	0.065
50	0.115
70	0.270

To measure the vapor pressure of water in the 4 per cent detergent solution, the method was used in which air is bubbled through the liquid. In order to obtain a continuous reading, the sensing element of an electric hygrometer was placed in the apparatus above the liquid level, so that the air, after bubbling through the liquid, would pass over the element of the hygrometer. This gave a continuous reading of the relative humidity of the air that had been bubbled through the liquid. This of course was not a direct reading of water vapor pressure but rather a function of vapor pressure. What the hygrometer really showed was P/P_0, where P is the partial pressure of water in the solution and P_0 the vapor pressure of pure water at that temperature. The term P/P_0 is the same as relative humidity and is sometimes referred to in the literature as "relative vapor pressure." In this case, the relative vapor pressure of water was much more useful to us than the actual vapor pressure.

In earlier experiments the detergent solution was pumped through a 6-ft U tube made from 1½-in. pipe, and air was bubbled through the U tube countercurrent to the solvent flow. Since then the apparatus shown in Fig. 2 has been devised which employs a 1-liter 3-necked flask, is much more compact, uses a much smaller sample of solvent, and can be easily placed in a constant temperature bath. The stirrer is made of glass tubing and acts as a centrifugal air pump. As the impeller of the stirrer revolves it throws air out from its two ends into the solvent solution. The air bubbles through the solution, then leaves the flask and passes over the element of an electric hygrometer, and finally again enters the apparatus at the upper portion of the stirrer for recirculation. At each concentration of water being investigated, the stirrer is allowed to circulate the air until the electric hygrometer needle no longer drifts, indicating that equilibrium has been reached.

Figure 3 shows results of such measurements made at 75 F using a 4 per cent solution of detergent A in Stoddard solvent. The concentration of water is plotted against P/P_0 of the solvent. From many such measurements, the slope of the curve has been found to vary considerably with different detergents and with different concentrations of the same detergent. However, the shape of the curve is usually the same and usually the solution does not become cloudy until P/P_0 is higher than 0.90. With a few of the products, diluting the solutions with pure solvent was tried. Dilution did not alter P/P_0 of the solution, indicating that P/P_0 depends on the ratio of detergent to water for any particular products.

Significance of Relative Vapor Pressure of Water

In Fig. 3 the three points from Table I have been added. It was felt that within the limits of the experimental error these three points lie on the P/P_0

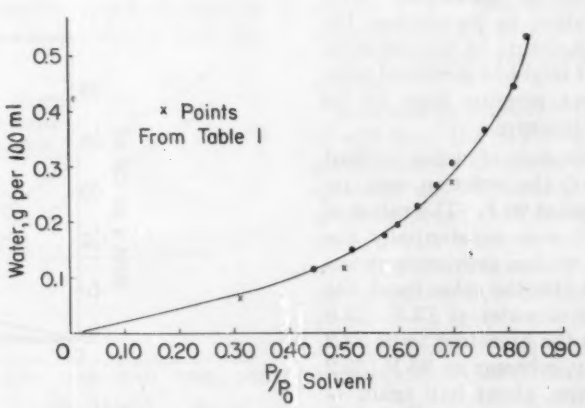


Fig. 3.—Relationship Between Per Cent Water and the Relative Vapor Pressure of Water in a 4 Per Cent Solution of Detergent in Stoddard Solvent.

curve. This indicates that the relative vapor pressure of water in the solvent is in equilibrium with the relative vapor pressure of water in the air (the relative humidity) and also is in equilibrium with the moisture in textiles. Moreover, textiles in equilibrium with the solvent are also in equilibrium with the relative humidity of the air that has been bubbled through the solvent. When explaining this principle to drycleaners, the authors use a diagram showing air being bubbled through a column of solvent with one piece of wool immersed in the solvent and a second piece suspended in the air above the solvent. It is explained that the two pieces of wool absorb the same per cent of water.

This equilibrium is more easily understood from the diagram shown in Fig. 4.

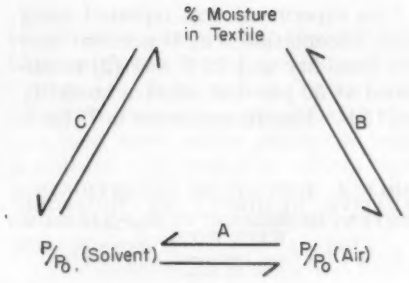


Fig. 4.—Equilibria that Exist During a Drycleaning Process.

The equilibrium at point *A* must exist provided the air is allowed to mix intimately enough with the solvent, for the vapor pressure of water in the solvent must come to equilibrium with the partial pressure of water in the air. If the vapor pressures are in equilibrium, then P/P_0 for the solution and for the air must also be in equilibrium since P_0 (the vapor pressure of pure water) is the same for both sides of the equation. The equilibrium at point *B* between the per cent moisture in a textile and the relative humidity in the air has been established for many years. All the authors are pointing out is that a similar equilibrium exists at point *C*. So long as the equilibriums at points *A* and *B* exist, it becomes obvious that a similar equilibrium must exist at point *C*.

The authors would like to have had more data to present to establish that this equilibrium exists at point *C*. However, during the past year their research has disclosed nothing to refute it. For example, many reports from the field have indicated that in cases where the drycleaning solvent has become rather warm (90 to 95 F) there has been more wrinkling of garments. This caused speculation as to whether the absorption of moisture by textiles in an organic solvent might be governed more by water vapor pressure than by its relative vapor pressure.

The determination of water content *versus* P/P_0 of the solution was repeated, this time at 90 F. The values of P/P_0 at 90 F were substantially the same as those we had previously determined at 75 F. On the other hand, the vapor pressure of water at 75 F (23.9 C) is shown in the literature to be 22.2 mm of mercury, whereas at 90 F (32.2 C) it is 36.1 mm, about half again as much. Thus if the moisture pickup of textiles depends on the vapor pressure of water in an organic solvent rather than the relative vapor pressure, the textile should pick up considerably more water at 90 F than at 75 F (more recent experiments have shown that increasing the solvent temperature to 100 F or above increases the relative vapor pressure of water in the solvent).

The authors repeated, at 90 F, the experiment to determine the amount of moisture wool picks up from the 4 per cent detergent solution after the wool had been conditioned at 70 per cent relative humidity and 75 F and the points determined at 90 F were added to Fig. 1. Raising the solvent temperature from 75 to 90 F obviously made no substantial change in the amount of moisture the fabric picked up. Thus the moisture pickup seems to depend on the relative vapor pressure rather than the vapor pressure of water in the solvent. In fact, the relative vapor pressure of water (P/P_0) in a drycleaning solvent has become so important to us that we now refer to it in our bulletins to the drycleaning trade as the "solvent-relative humidity."

Figure 5 shows relative vapor pressure data for a Stoddard solvent solution of another popular detergent, referred to as detergent *B*. Here data are shown for two concentrations of detergent, both 4 per cent and $\frac{3}{4}$ per cent—the latter being a common detergent concentration used in the more dilute type of charged system. The right side of the graph from 0.85 up has been shaded and called a "dangerous area." If the solvent stays in the dangerous area too long while garments are being drycleaned, the garments will suffer detrimental effects such as wrinkling (which greatly increases the time required for pressing) and shrinkage. The line at 0.85 is of course an approximation. Actually, there are some fabrics that begin to show deterimental effects when the relative vapor pressure gets above 0.80.

Figure 5 illustrates what happens in a drycleaning system when moisture is added. Suppose the drycleaner is using the more dilute form of the charged system—that is, a $\frac{3}{4}$ per cent solution of detergent. At the beginning of the run the solvent contains some water and will probably be at approximately point *A*. The drycleaner puts the garments into the washer and adds an emulsion of water—often about $\frac{1}{2}$ oz of water per lb of load (approximately 3 per cent water on the basis of the weight of the garments). When this water is added to the solvent the condition of the solvent moves to approximately point *B*. The solvent now has a much higher relative vapor pressure of water than that with which the garments are in equilibrium. The condition of the solvent then moves back along the line and finally stops at approximately point *A*, the exact point depending on the amount of moisture the garments contained before being put into the washer. If the solvent did not

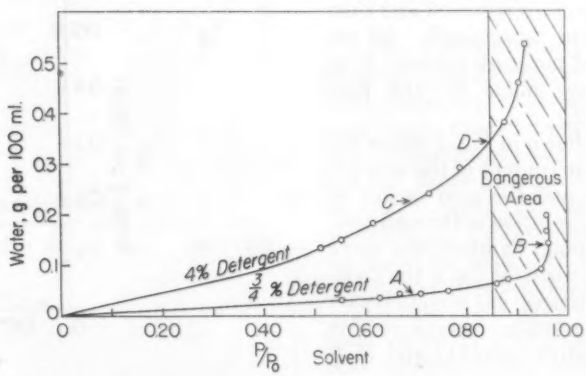


Fig. 5.—Relationship Between Per Cent Water and Relative Vapor Pressure of Water in $\frac{1}{4}$ Per Cent and in 4 Per Cent Detergent Solutions in Stoddard Solvent.

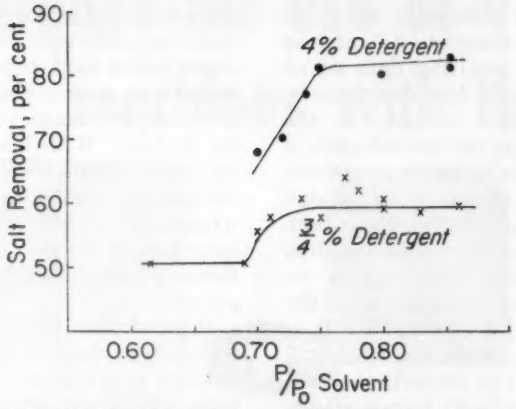


Fig. 6.—Relationship Between the Relative Vapor Pressure of Water and Removal of Water-Soluble Soil.

stay in the dangerous area more than a few minutes, probably no wrinkling or shrinkage occurred.

Let us assume now that the drycleaner is using a 4 per cent solution of detergent. The 4 per cent curve is much steeper than the ¾ per cent curve. He will again start with some water in the solvent, probably somewhere around point *C*. Assuming he adds the same amount of water to the solvent, the relative vapor pressure of water in the solvent will rise to approximately point *D*. During the drycleaning process it will gradually drop back again to about point *C*.

Earlier in this paper it was stated that when drycleaning with the 4 per cent solution the detrimental effects of added water, such as wrinkling or shrinkage, were not encountered. Figure 5 shows the reason. With the 4 per cent solution the dangerous area was never entered.

Controlling the Relative Vapor Pressure

This continuous changing of the relative vapor pressure of water during a drycleaning operation naturally complicates the interpretation of data when running test loads. To eliminate this difficulty and to dryclean under more reproducible conditions, a method was devised for holding the relative vapor pressure of water constant during an entire drycleaning process. This method has been revised several times since.

It has been found that while the cylinder of the washer is turning, the air inside the washer is in equilibrium with the solvent. To measure the relative vapor pressure of water in the solvent, it is merely necessary to draw air from the washer and pass it over the element of some instrument that measures the relative humidity of the air. There are several elements of an electric hygrometer mounted within a small round can, approximately 3½ in. high and 3¼ in. in diameter, mounted on the top of the washer. By means of a water aspirator, a current of air is drawn constantly from the washer and through the can. To maintain the can at the same temperature as the solvent, a coil of copper tubing is soldered around the outside of the can. Solvent is constantly bled off the filter line, passes through this copper coil, and then empties into the button trap.

The hygrometer elements are connected to an Aminco electric hygrometer controller, manufactured by the American Instrument Co., Catalog No. 4-4924. This instrument contains an electrical relay. It can be set at any desired relative vapor pressure (relative humidity). If the load is to be drycleaned at a relative vapor pressure of 0.80, the electric hygrometer is first set for 80 per cent relative humidity. If the relative vapor pressure of the solvent is below this, the hygrometer controller opens a solenoid valve that in turn allows an emulsion of water, solvent, and detergent to trickle into the button trap. The filter pump is started and the solvent is brought up to the desired relative vapor pressure, at which point the electric hygrometer controller closes the solenoid valve. The garments are then put into the washer. As the garments pick up water from the solvent, the relative vapor pressure of water in the solvent drops, and the electric hygrometer controller again opens the solenoid valve, allowing the emulsion of water to trickle into the button trap, until the relative vapor pressure of water in the solvent is again up to 0.80. In this manner a load can be drycleaned, holding the relative vapor pressure of water in the solvent fairly constant.

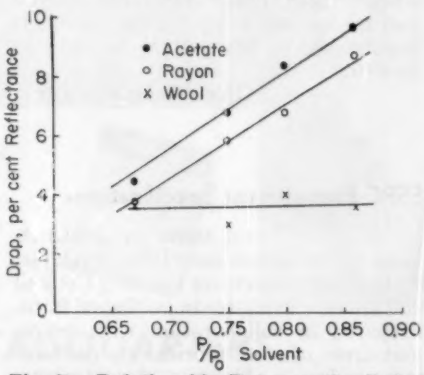


Fig. 7.—Relationship Between the Relative Vapor Pressure of Water and Whiteness Retention.

Water-Soluble Soil Removal

This method has allowed the effects of the relative vapor pressure of water on drycleaning to be studied. A number of detergents have been used at both 4 and at ¾ per cent concentrations. The results shown were obtained in a 30- by 30-in. monel cylinder washer using Stoddard solvent, and connected to a filter circulating solvent in the washer at a rate of 30 solvent changes per hour. The loads consisted of 25 lb of dark colored dresses soiled through actual wear. Each load was conditioned at 50 per cent relative humidity and 75 F for at least 2 hr before being cleaned. Each load ran for 30 min with constant filter circulation. During each load the relative vapor pressure of water was held constant.

Figure 6 shows how the relative vapor pressure of water in the solvent affects the removal of water-soluble soil, as shown by our salt swatches. It is interesting to note that the higher detergent concentration, which of course holds more water in solution, removed much more salt than did the lower detergent concentration.

It is the authors' belief that this higher removal of water-soluble soil is the main advantage of the stronger charged system (3 to 4 per cent). Since this work has been done hundreds of drycleaning plants have reported that adopting the stronger concentration of detergent has substantially reduced their spotting and wet-cleaning costs.

It is of some interest to note that a maximum in removal of salt was reached at a relative vapor pressure of approximately 0.75. This indicates that the range of from 0.75 to 0.80 is the desirable range in which to operate a drycleaning system.

It should be pointed out that removal of salt from the swatches must be regarded merely as relative. Salt is considerably more difficult to remove from some swatches than from others. Although salt removal on the various swatches taken from any one strip can be compared, it is difficult to soil different strips exactly the same. All the results shown in this graph were done with swatches taken from the same strip.

Whiteness Retention

By using the method of controlled relative vapor pressure of water, it was

possible to investigate whiteness retention during drycleaning. These test loads all consisted of dark colored garments which invariably contain more soil than light colored garments. Results of some typical loads using a 4 per cent solution of detergent B are shown in Fig. 7. It is interesting to note that redeposition of soil increases on rayon and acetate as the relative vapor pressure of water increases but does not substantially increase on wool.

The stronger concentration of detergent has not been found to have any particular advantage over the more dilute charged system from the standpoint of whiteness retention. For example, when using a $\frac{3}{4}$ per cent concentration of detergent A, six test loads were run with the relative vapor pressure of water in the range of 0.70 to 0.80. On these six loads the average drop in reflectance of white rayon was 5.4, of white acetate was 6.3, and of white wool was 3.6. Using a 4 per cent solution of the same detergent, four loads were cleaned at approximately the same relative vapor pressure (actually these varied from 0.72 to 0.75). In this case, the average drop in reflectance on white rayon was 5.6, on acetate 5.7, and on wool 2.9. These and other data are on hand to bear out the fact that the relative vapor pressure of water in the solvent, rather than the concentration of detergent, is a major factor in governing redeposition of soil on rayon and acetate. Although studies have been made with several different detergents, it should be pointed out that by no means has a survey been made of all the detergents offered to the trade. It is quite possible that there are detergents (or that some can be devised) that will perform more effectively from a standpoint of whiteness retention.

Insoluble Soil Removal

Attempts were made to correlate the relative vapor pressure of water in the solvent with the removal of insoluble soil. The authors were not able to obtain a very good correlation; removal of insoluble soil did not seem to be much different at a relative vapor pressure of 0.65 than at 0.85. It was found, as might be expected, that the stronger concentration of detergent removes more insoluble soil. With the carbon-soiled pieces used, increases in per cent reflectance were normally obtained of about 30, by running in distilled solvent for 30 min. With loads cleaned in $\frac{3}{4}$ per cent concentration of detergent, reflectance is usually increased to about 44 per cent, while with loads run for the same time in a 4 per cent detergent, reflectance usually increases to about 60 per cent.

In conclusion, the drycleaning industry needs products that will enable drycleaners to obtain a higher removal of water-soluble soil, without operating at a high enough relative vapor pressure of water to cause detrimental effects, such as wrinkling and shrinking of textiles. The authors' experience indicates that one way of increasing removal of water-soluble soil is to increase the solubilization of water. Thus a product with a steep relative vapor pressure curve holds more water in solution without raising the relative vapor pressure of water above 0.85. The authors' work indicates that this is a very desirable attribute of a drycleaning detergent.

NOTES ON BOOKS

Refractory Hard Metals

In "Refractory Hard Metals—Borides, Carbides, Nitrides, Silicides," Schwarzkopf and Kieffer present a review of the literature and some previously unpublished knowledge. This book deals with the preparation and properties of the refractory and hard carbides, nitrides, borides, and silicides of the transition elements. According to the preface of the book, the authors are preparing a separate volume which will describe the production and applications of cemented hard metals, that is, the materials ultimately produced for commercial use from the basic borides, carbides, nitrides, and silicides. With this middle part of their story untold, the authors use the last one-sixth of the 447-page volume to discuss materials for service at elevated temperature. This temporary discontinuity in the presentation of the subject will leave the neophyte with some vague ideas but does not detract from the general usefulness of the book.

This highly technical book contains a wealth of information. The authors have linked the data so that the reader will have a smooth thought transition throughout the mass of information. This is quite an accomplishment. It is not surprising to find a few minor errors in so many data. Examples are the reference to the "partial pressure of carbon" (page 143), and a typographical error (V_2B_5 instead of V_2O_5) on page 287.

The speed of technological developments and the lag in publication of plant processes are a real handicap to technical book authors. In reading this book, therefore, the reader should realize this point and consider that all of the very latest thoughts and practices may not have been included in every case. For example, the authors describe the production of fused W_2C. Actually, the product of great commercial importance is a eutectic of WC and W_2C. This material is produced in the United States by a process much simpler than the one the authors describe and the problems involved are not so great as one would infer from the authors' description.

Undoubtedly the book will be useful to research and development personnel, not only to those working on new materials but also to many whose work involves the materials we would like to term metalides.

The book contains an author and subject index, many references, figures, and tables, and a few photographs. It is published by Macmillan Co. and sells for $10.

Roland B. Fischer

SSPC Pretreatment Specifications

Four tentative pretreatment specifications have been developed by the Steel Structures Painting Council and are now available in published form. Prepared in collaboration with representatives of steel fabricators, contractors, railroads, highway departments, paint manufacturers and contractors, and other interested organizations, it is intended that these specifications be included in contracts by reference to their title and number. Suggestion for improvement should be addressed to the Secretary, Steel Structures Painting Council.

The newly published specifications cover: No. 1, Wetting Oil Treatment; No. 2, Cold Phosphate Surface Treatment; No. 3, Basic Zinc Chromate-Vinyl Butyral Washcoat; No. 4, Hot Phosphate Surface Treatment.

A complete set of these specifications can be obtained from the Steel Structures Painting Council, 4400 Fifth Ave., Pittsburgh 13, Pa., for 60 cents. Single copies of the separate specifications may be had for 25 cents.

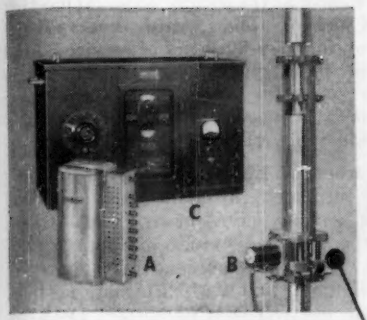
Textbook of Engineering Materials

Melvin Nord, of Wayne University, has collected under one cover, a systematic study of the materials of engineering.

The first half embraces the sources and recovery of mineral wealth, the principles of refining these materials, and their properties. The second half of the book is devoted to discussions of the individual materials with reference to their primary properties and uses.

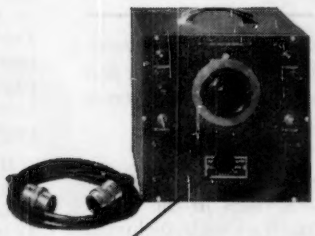
The chapters on fuels, explosives, metals, synthetics, natural materials, and so forth, provide interesting and informative reading for an early college level. John Wiley & Sons Co., Inc., New York 16, N. Y. 518 pp., $6.50.

Increase the use of your Baldwin Testing machines with these accessories



High Temperature Testing Equipment

Includes *electric furnace* (A), *high temperature extensometer* (B), and *temperature controller* (C) which enable you to test metals at high temperatures. Various models are available for temperatures up to and including 2200° F.

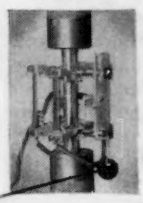


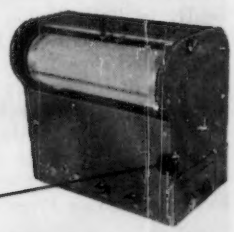
Extension Under Load Indicator

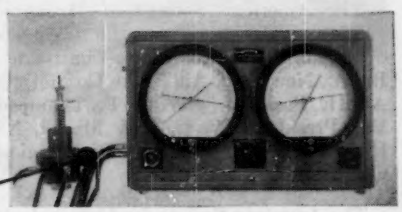
Used with a microformer type extensometer, this indicator will give you both a visual and audible signal at any desired predetermined amount of extension under load (such as 5% of the gage length).

SR-4 Extensometer and Strain Gage Recorder

This records on a chart a load-elongation graph for determining the elastic and plastic properties of materials. Various types are available.

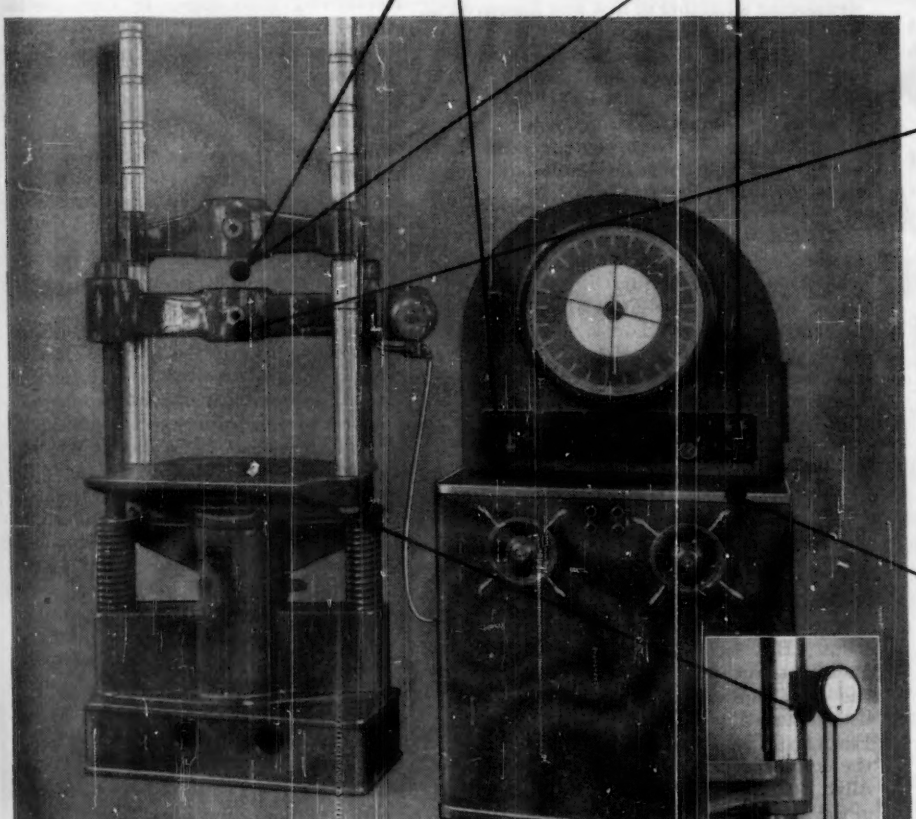


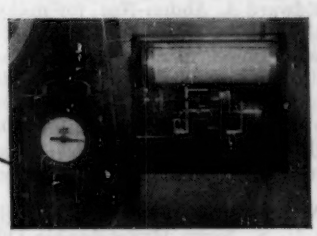




Air Cell (with Bourdon tube-type indicators)

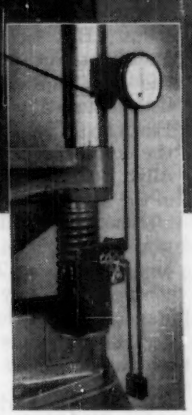
Inserted in the grip slot and arranged to work with the testing machine indicator or a portable indicator, the Air Cell extends the precision ranges down to one pound full scale on any machine. This permits testing of light materials such as plastics, textiles, wood, foils, fibers, etc. with machines intended for higher capacities. (Bulletin 264.)





Strain Rate Pacer

(Shown with Microformer Recorder.) This device enables you to maintain percisely a constant straining rate of the test specimen gage length during the loading of the test specimen. Standard pacing speeds from .00025 to .25 inch per minute are available.



Ram Pacer

This controls ram speed at desired rate (8 pacing speeds, from 0.01 to 1.0 inch per minute). Enables you to meet test specifications. High magnification types for infinitely variable speeds from 0.002 to 4.0 inches per minute also available.

BULLETIN 261-A, a 12 page booklet, illustrates and describes fully Baldwin's line of grips, accessories and auxiliary equipment. Write Dept. 2303, Baldwin-Lima-Hamilton Corporation, Philadelphia 42, Pennsylvania.

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PERSONALS...

News items concerning the activities of our members will be welcomed for inclusion in this column.

NOTE—*These "Personals" are arranged in order of alphabetical sequence of the names. Frequently two or more members may be referred to in the same note, in which case the first one named is used as a key letter. It is believed that this arrangement will facilitate reference to the news about members.*

At the 44th annual convention of the American Electroplaters Society held recently in Philadelphia, **George P. Swift,** Consulting Engineer, Watertown, Mass., was elected President. For many years a member of the faculty of the Massachusetts Institute of Technology, Dr. Swift is a recognized authority in his field. **R. A. Schaefer,** of the Clevite-Brush Development Co., Cleveland, Ohio, was elected first Vice-President.

The American Society of Mechanical Engineers has announced the nomination of **Lewis K. Sillcox,** Vice-Chairman of Board, New York Air Brake Co., for 1954 ASME President. **Willis F. Thompson,** Vice-President, Westcott & Mapes, New Haven, Conn., was one of five regional vice-presidents nominated.

The American Society for Metals elected as their President **J. B. Austin,** Director, Research Laboratory, U. S. Steel Corp., Kearny, N. J. **George A. Roberts,** Chief Metallurgist, Vanadium Alloys Steel Corp. Latrobe, Pa., was named Vice-President.

Robert W. Abbett, partner in the New York City firm of Knappen Tippets-Abbett-McCarthy, received an honorary degree of Doctor of Science from Gettysburg College.

Edward A. Abdun-Nur, for many years with the U. S. Bureau of Reclamation, has opened offices in Denver, Colo., as Consulting Engineer in the soils field. Mr. Abdun-Nur has been especially active in the work of ASTM Committee D-18 on Soils for Engineering Purposes, rendering valued service in many of its subgroups.

Nathaniel M. Adams, Jr., formerly with the U. S. Navy Hydrographic Office in Suitland, Md., is now serving on the staff of the National Bureau of Standards, Washington, D. C., as Mechanical Engineer.

James H. Bly, until recently Radiographer, Materials Control Lab., Pratt & Whitney Aircraft Div., United Aircraft Corp., East Hartford, Conn., is now associated with X-ray, Inc., Highland Park, Mich. Mr. Bly has been Chairman of ASTM Committee E-7 on Non-Destructive Testing since 1948, previously serving for two years as Secretary of this group.

J. Robert Bonnar, of the General Dyestuff Corp., New York City, has been named Sales Manager of the Dyestuff Division. He was formerly Manager of the Dyestuff Technical Division.

Darwyn I. Brown, widely known as an author of technical articles in the metal working field, and until recently technical editor of *Iron Age,* has joined Mullins Manufacturing Corp., Warren, Ohio, as Market Development Manager of the Koldflo Division.

Donald S. Bruce, for the past nine years head of the Research Department of The Gummed Products Co., Troy, Ohio, has been elected Vice-President in Charge of Research. Under Mr. Bruce's direction his company has been successful in developing a number of new and improved adhesives. A member of ASTM since 1944, Mr. Bruce is active in the Society's Ohio Valley District Council.

John F. Campbell, formerly with the Cabot Carbon Co., has accepted a position as Adjuster and Solicitor, Panhandle Insurance Agency, Pampa, Tex.

A. Ludlow Clayden, Technical Associate in the Chemical Research and Development Department of Sun Oil Co., Marcus Hook, Pa., has retired after 31 years with the company. An authority on fuels and internal combustion engines, Mr. Clayden has been active in many subgroups of Committee D-2 on Petroleum Products and Lubricants.

Charles H. Commons, Jr., formerly with the Illinois Electric Porcelain Co., Ma-Comb, Ill., is now Head, Ceramic Dept., Research Lab., Foote Mineral Co., Berwyn, Pa.

Container Laboratories recently announced important changes in its management. **Henry J. Howlett** has retired as President, and will serve as consultant to the organization. The presidency has been assumed by **Charles J. Zusi,** formerly Executive Vice-President, who has been in the employ of the company for 12 years. **Allyn Beardsell** has been named Manager of the Eastern Division with headquarters in New York. **Alfred Hoffman,** for many years Manager of the New York Laboratory, has become Technical Director of the company. **Harry Kattelmann** retains managership of the San Francisco Laboratory, and **Thomas Wharton** guides the recently established Washington office.

R. H. Cubberley, formerly Assistant Research Director, The Flintkote Co., has been named Director of Research for all divisions of the company. His office will be located at the Flintkote Research Laboratory at Whippany, N. J.

Roland E. Derby, head of the Derby Co., and of Textile Aniline & Chemical Co., Lawrence, Mass., is recipient of the 1953 Olney Medal, top award of the American Association of Textile Chemists and Colorists, presentation being made this month at the society's annual meeting in Chicago. The award honors Mr. Derby for over 30 years of service to the textile industry, and at the same time pays special tribute to the memory of Louis A. Olney, founder and long-time president of AATCC.

Herbert A. Ehrman has taken involuntary retirement after 42 years' Government service. For many years Chief, Textile Section, Division of Trade Standards, U. S. Department of Commerce, Washington, D. C., Mr. Ehrman has been active in ASTM Committee D-13 on Textile Materials and is currently Secretary of the Subcommittee on Test Methods. He plans to enter some phase of industry.

Paul D. Foote, Executive Vice-President of Gulf Research & Development Co., Pittsburgh, Pa., was awarded an honorary Doctor of Science degree by Carnegie Institute of Technology. Dr. Foote, also Vice-President of Gulf Oil Corp. and Gulf Refining Co., is the eighth person in the school's 53-year history to receive an honorary degree.

John R. Freeman, Jr., for many years Technical Manager, has been named Vice-President of Metallurgy and Research, The American Brass Co., Waterbury, Conn.

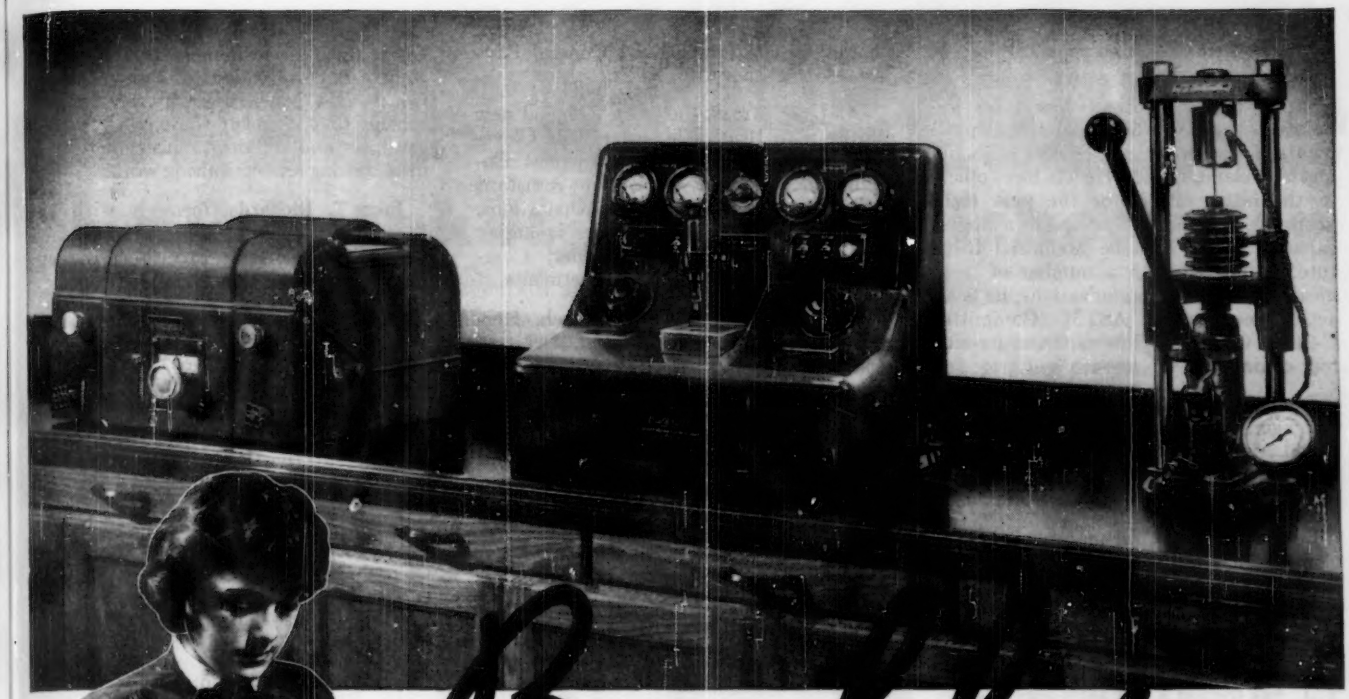
Nathaniel Howell Furman, Professor of Chemistry and Chairman of the Department, Princeton University, has been selected to receive the 1953 Palladium Medal of The Electrochemical Society, presentation to be made this month at a dinner in Professor Furman's honor during the Fall Meeting of the Society at Wrightsville Beach, N. C. He is cited for "outstanding contributions to the field of analytical chemistry and particularly for his successful application of electrochemical principles to the development of new methods and techniques of chemical analysis". A long-time member of ASTM, Professor Furman serves on Committee E-3 on Chemical Analysis of Metals, and numerous of its subgroups.

Ray C. Giddings, formerly with Metallurgical Engineers, Inc., Portland, Ore., is now associated with A & R Redimix, Arcata, Calif., as Field Engineer.

J. B. Goldberg, who recently resigned as Research Director of J. P. Stevens and Co., has opened offices in New York City to provide technical consulting services to the textile and allied industries. Mr. Goldberg has been identified with the textile industry for the past 25 years, and is author of the book "Fabric Defects."

J. D. Hanawalt, since 1946 Manager of the Magnesium Department, Dow Chemical Co., Midland, Mich., has been named a Vice-President.

(Continued on page 74)



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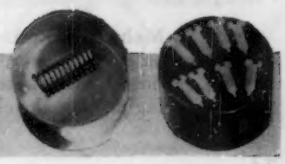


(*Continued from page 72*)

Cameron G. Harman has been appointed Head of the Ceramics Department, Horizons, Inc., of Princeton, N. J., and Cleveland, Ohio. He will have offices in the latter city. For the past eight years Dr. Harman has served in a similar capacity at the Battelle Memorial Institute. Affiliated with a number of technical and scientific organizations, he is an active member of ASTM Committee C-21 on Ceramic Whiteware and its current chairman.

George H. Hotte has been appointed Manager of Synthetic Fiber Sales, National Aniline Div. of Allied Chemical & Dye Corp. He was formerly with A. M. Tenney Associates, Inc., New York City.

Cedric E. Hulme, for many years Chief Control Chemist, Kendall Refining Co., Bradford, Pa., is now Manager of Sales Engineering.

Wharton Jackson, formerly associated with the Georgia Kaolin Co., Elizabeth, N. J., has formed a new sales organization with headquarters in the Petroleum Building, Los Angeles, Calif., and Offices also in New York City, to represent companies dealing in nonmetallic minerals. Mr. Jackson has been actively engaged in the nonmetallic field for the past 20 years.

Armand E. Keeley, President, Prismo Safety Corp., Huntingdon, Pa., has been elected chairman of the Committee on Traffic Control Devices of the American Road Builders Association. The membership of the committee is comprised of manufacturers of reflective markings and materials for signs and highways, and is the national organization of the highway marking and signing industry.

J. B. Kommers has retired as Professor of Mechanics, Engineering College, University of Wisconsin, Madison. An ASTM member for the past 40 years, Professor Kommers has served on Committees A-3 on Cast Iron and E-9 on Fatigue.

Don A. Lawless, a specialist with 25 years' experience with light metals, has joined the Metallurgy Department of Sam Tour & Co., Inc., New York City, research and testing organization. Prior to joining the Tour Co., Mr. Lawless was employed at the Kaiser Aluminum and Chemical Corp., Spokane, Wash.

J. R. MacGregor has been appointed to the newly-created post of Research Coordinator, Petroleum Products, with the California Research Corp., San Francisco, Calif.

S. C. Massari recently resigned as Technical Director of the American Foundrymen's Society to assume the position of General Manager of the Foundry Division, Hansell-Elcock Co., Chicago, Ill.

Frank J. Mehringer, formerly Research and Development Engineer, Victory Plastics Co., Hudson, Mass., is now on the staff of the Engineering Development Lab., Knoll Atomic Power Lab., General Electric Co., Schenectady, N. Y.

A. J. W. Novak has been assigned new duties with Brush Electronics Co., Cleveland, Ohio. Formerly Commercial Engineering Manager, he is now Assistant General Sales Manager for Operations, heading all line sales activities including the Equipment, Tape Recorder, Component, and International Departments.

Emil Ott, Director of Research, Hercules Powder Co., Wilmington, Del., recently attended a series of international science meetings, as a delegate from scientific organizations in the United States, visiting Switzerland, Germany, France, The Netherlands, England, Denmark, and Sweden.

Jaro J. Polivka, Consulting Engineer and Lecturer, University of California, Engineering Dept. Berkeley, received the French Legion of Honor Medal of Etoile de Benin, presentation being made by Louis de Guiringaud, Consul General of France at San Francisco, at a recent meeting of the Alliance Francaise.

Malcolm M. Renfrew, formerly Director of Chemical Research at General Mills Research Laboratories, Minneapolis, Minn., has been named Director of Chemical Research and Development, assuming over-all administrative responsibility for the departments concerned with chemical research, chemical engineering, and chemical market development.

Theodore O. Reyhner, until recently on the faculty of the Michigan College of Mining and Technology, Department of Civil Engineering, Houghton, is now Associate Professor of Civil Engineering, College of Engineering, University of Denver.

Herbert B. Reynolds, who has been associated with the J. G. White Engineering Corp. since his retirement from the position of Superintendent of Power Generation for the New York City Transit System in 1949, has left the employ of that company and will devote his time to technical writing and consulting work.

John T. Richards, formerly with The Beryllium Corp., Reading, Pa., is now Chief Engineer, Penn Precision Products, Inc., in the same city.

Paul L. Salzberg, formerly Assistant Director of Chemical Department, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del., has been promoted to Director, succeeding the late Cole Coolidge. Mr. Salzberg also succeeds Mr. Coolidge as representative of the du Pont Sustaining Membership in ASTM.

Joseph J. Shideler, until recently with the U. S. Bureau of Reclamation, Denver, Colo., has joined the staff of the Research and Development Laboratory of the Portland Cement Assn., Chicago, Ill., as Development Engineer.

Henry Paul Whitten, has accepted a position as Physicist, Textile Section, Southern Research Institute, Birmingham, Ala. He was formerly with the Celanese Corp. of America, Rock Hill, S. C.

Harold W. Wilson, has announced establishment of the Wilson Chemical & Testing Laboratory, El Paso, Tex. He was previously associated with the American-Marietta Co., Kankakee, Ill., as Chief Analytical Chemist.

C. H. Zieme has retired after 42 years' continuous service with the Republic Rubber Division, Lee Rubber and Tire Corp., Youngstown, Ohio. A long-time ASTM member, his affiliation dating from 1915, Mr. Zieme has been an active participant in the work of Committee D-11 on Rubber and Rubber-Like Materials, serving on many subgroups.

ASTM Members in National Bureau of Standards Honored

NBS men honored this year with Department of Commerce Exceptional Service Awards, recognizing outstanding contributions to the public service, the nation, or humanity, included the following ASTM members, all of whom have had an active part in the nation's standardization program: William D. Appel, Gordon M. Kline, George N. Thompson, and Elmer Weaver.

Mr. Appel, a member of the Bureau staff since 1922, and now Chief of the Textiles Section of the Organic and Fibrous Materials Division, has participated for many years in the activities of ASTM Committee D-13 on Textile Materials and is the present chairman of this group. He received the Exceptional Service Award for his "outstanding contributions to textile chemistry, technology, and standards for many years at the National Bureau of standards." The citation declares, "His pioneering work in the utilization of spectrophotometry in the investigation of dyes and dyeing led to a new approach to the problems of dyeing and fading of textiles and anticipated technological developments in textile dyeing." Concerning his work as Chief of the Textiles Section, it continues, "The varied program of research and developmental work in the textiles section led to a whole series of testing machines and procedures that are widely used in research and in specifications, and has maintained the National Bureau of Standards in a position of leadership in the rapidly developing technical activities in this field, both nationally and internationally."

Dr. Kline, Chief of Division of Organic and Fibrous Materials and associated with NBS since 1929, is a Past-Chairman of ASTM Committee D-20 on Plastics, also Past-Chairman of the ASTM Washington (D. C.) District Council. He received the gold medal award for his "major contributions to science and technology through pioneering work and accomplishments in the field of organic plastics and for distinguished authorship. Nomination for the

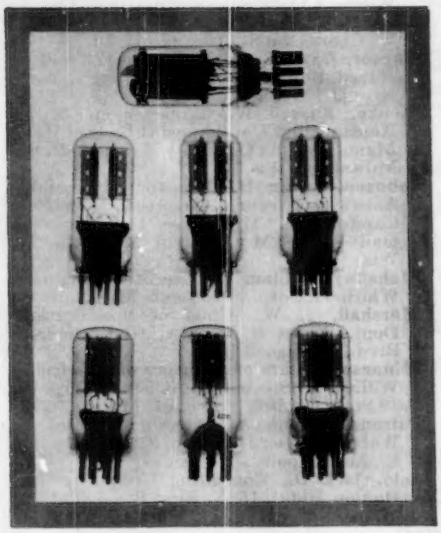
(*Continued on page 76*)

one minute
is all it takes to get finished, dry radiographs

* NOTE: Reduction to 1/5 size, combined with image decay incident to the printing process, seriously degrades in these miniature reproductions the fine detail of the 10" x 10" originals.

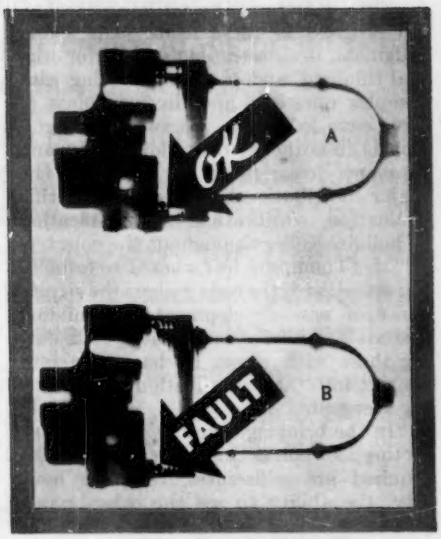
Subject: **IGNITION CABLE ELBOW** (Ignition cable elbows filled with insulating sealing compound.)
Objective: To confirm winding spacing alignment of center wire.
Disclosed: Gas bubbles in elbows where compound failed to fill.

like



Subject: **ELECTRONIC TUBES**
Objective: To confirm alignment and spacing of elements.
Disclosed: All elements correctly oriented.

these*



Subject: **CAST ALUMINUM GASOLINE FILTER**
Objective: To confirm correct placement of gasket after completion of assembly.
Disclosed: (A) Correct assembly (B) Fractured gasket slipped out of place.

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(*Continued from page 74*)

award emphasized that his recent appointment as Division Chief is a tribute to his administrative abilities as well as his versatility, breadth of interest, and imagination. It further stated, "Recognition of Dr. Kline's international reputation in the field of plastics is shown by his selection as a representative to England to exchange information with plastics experts there regarding military applications of plastics during 1942, and his selection as the first chairman of the Technical Committee TC 61 of the International Organization for Standardization."

Mr. Thompson, a member of NBS Staff since 1924 and now Assistant Chief of the Building Technology Division, has long been active in ASTM Committee E-5 on Fire Tests of Materials and Construction, serving on many subgroups and heading the Subcommittee on Fire Tests of Materials Construction. His award recognized "rare and outstanding contributions to higher standards of housing through the development of model building codes," the citation further stating in part:

"Mr. Thompson's contributions to the national housing effort, industrial safety, and building materials development and standardization have achieved major proportions as factors in scientific and technical progress in these fields. His sound judgment, demonstrated capacity for original thinking, and successful dealing with complex questions and diverse points of view have led to his widespread recognition as an authority on building codes and to many demands on his services. His major contribution has been the scientific evaluation, clarification, and unification of building codes throughout the country.

"Mr. Thompson has worked to bring to the attention of the code makers the significance of new developments in building materials, skillfully and tactfully stimulating those with whom he has come into contact into the reconciliation of conflicting viewpoints.

"In the bringing together of these conflicting viewpoints the particular qualities required are selflessness, complete honesty, the ability to see the other man's point of view, a firm belief in one's mission (but the willingness to make haste slowly), a strong technical background, and acquaintance with both laboratory results and practical problems. Mr. Thompson possesses all of these qualities."

Mr. Weaver, Chemist on the NBS staff 1912, has been a member of ASTM Committee D-3 on Gaseous Fuels for many years. He was cited for "important basic contributions to the knowledge of the chemical behavior of gases," his major contributions being the thermal conductivity method of gas analysis, and the development of methods for designing gas burners and for testing domestic gas appliances for safety, efficiency, and durability. His citation further stated that he had contributed to research on the interchangeability of gases, and was a pioneer in demonstrating the soundness and advantages of the practice of purchasing gas on the basis of heating value.

NEW MEMBERS...

The following 101 members were elected from June 25 to August 25, 1953, making the total membership 7545 . . . Welcome to ASTM

Note—Names are arranged alphabetically—company members first then individuals

CHICAGO DISTRICT

Fast and Co., John E., W. S. Franklin, Vice-President and Chief Engineer, 3123 N. Crawford Ave., Chicago 41, Ill.

Ohmite Manufacturing Company, D. T. Siegel, President, 4835 W. Flournoy St., Chicago 44, Ill.

Spring Packing Corp., John P. Miller, Jr., Technical Div., 332 S. Michigan Ave., Chicago 4, Ill.

Vitreous Steel Products Co., Harold C. Wilson, Chief Chemist, Nappanee, Ind.

Blair, H. T., Precision Paper Tube Co., 2035 W. Charleston St., Chicago 47, Ill.

Causey, David Frederic, Engineer, Tracy A. Pitzen, Box 1, University Station, Urbana, Ill. [J]*

Henke, Russell W., Engineer in Charge, Research and Development, Badger Meter Manufacturing Co., 2371 N. Thirtieth St., Milwaukee, Wis.

Johnson, Arthur H., Director of Research, American Bowling Congress, 1572 East Capitol Dr., Milwaukee 11, Wis. For mail: 447 N. Morris Blvd., Milwaukee 11, Wis.

Mahaffay, William E., Executive Engineer, Whirlpool Corp., St. Joseph, Mich.

Marshall, J. W., Chief of Specifications Dept., Naess & Murphy, 80 E. Jackson Blvd., Chicago 4, Ill.

Minnesota, State of, Division of Purchases, William E. Stevenson, Assistant Director, 19 State Capitol, St. Paul 1, Minn.

Patronsky, Louis A., Director of Research, Wabash Screen Door Co., 2222 Elm St., S. E., Minneapolis 14, Minn.

Salo, Jack D., Consulting Civil Engineer, Dunlop Bldg., 15 E. First St., Duluth 2, Minn.

CLEVELAND DISTRICT

Gibson-Homans Co., E. J. Fisher, Director of Research, 2366 Woodhill Rd., Cleveland 6, Ohio.

Mallory-Sharon Titanium Corp., Israel M. Krauss, Metallurgist, Niles, Ohio.

Breeze, Lewis K., Director of Research, Glascote Products, Inc., 20900 St. Clair Ave., Cleveland 17, Ohio.

Brill, A. K., Development Manager, Republic Rubber Div., Lee Rubber and Tire Corp., Youngstown 1, Ohio.

Gray, Allen G., Technical Editor, *Steel*, Penton Publishing Co., 1213 W. Third St., Cleveland 13, Ohio.

Hochner, Royal M., Assistant Professor, Mechanical Engineering, Fenn College, Twenty-second and Euclid, Cleveland, Ohio. For mail: 15103 Triskett Rd., Cleveland 11, Ohio.

Koons, Harold O., Manager, Mechanical Engineering, The Electric Products Co., 1725 Clarkstone Rd., Cleveland 12, Ohio.

DETROIT DISTRICT

Levy, Edward C., Co., E. C. Levy, Jr., Engineer, 8800 Dix Ave., Detroit 9, Mich.

Dietiker, John D., Chief Laboratory Engineer, Vickers, Inc., 1400 Oakman Blvd., Detroit 32, Mich.

NEW ENGLAND DISTRICT

Riley Stoker Corp., F. E. Foster, Manager, Metallurgical Engineering, 9 Neponset St., Worcester, Mass. [S]**

New England Lime Co., F. S. White, Assistant to President, Adams, Mass.

Saco-Lowell Shops, Howard E. Handy, Chief Metallurgist, Biddeford, Me.

Ellis, Eugene W., Jr., Laboratory Engineer, Material Development Lab., Pratt & Whitney Aircraft, East Hartford, Conn.

Kunz, Warren J., Supervisor, Plymouth Cordage Co., Paper Twisting Div., Court St., Plymouth, Mass.

Savage, Robert L., Head Industrial Engineer, Corning Glass Works, 1193 Broad St., Central Falls, R. I.

Willy, John, Research Director, Glas-Kraft, Inc., Mill St., Lonsdale, R. I.

Wood, Horace D., Jr., Secretary, Wool Associates of the New York Cotton Exchange, Inc., 10 High St., Boston 10, Mass.

NEW YORK DISTRICT

Triangle Conduit and Cable Co., Inc., Gordon I. Donovan, Manager, Brass Sales, Triangle and Jersey Aves., New Brunswick, N. J.

Tung-Sol Electric, Inc., S. A. Standing, Director, CR Tube Div., 200 Bloomfield Ave., Bloomfield, N. J.

Benzing, E. H., American Bemberg, 261 Fifth Ave., New York 16, N. Y.

Ely, Robert J., Metallurgist, Metallurgical Dept., American Brake Shoe Co., Mahwah, N. J.

Fischer, Albert J., Director of Research, Adamas Carbide Corp., 1000 S. Fourth St., Harrison, N. J.

Frank, Jacob, Consulting Engineer, 50 Journal Square, Jersey City 6, N. J.

Hensley, Lester J., Engineer, Service Div., United States Testing Co., Inc., 1415 Park Ave., Hoboken, N. J. For mail: 71 Union St., Montgomery, N. Y.

Mallett, Frederick S., Research Manager, American Society of Mechanical Engineers, 29 W. Thirty-ninth St., New York City 18, N. Y.

Mutch, G. C., Research Dept., Revere Copper and Brass, Inc., Rome, N. Y.

Oliphant, George B., Vice-President, Caswell, Strauss and Co., Inc., Box 218, Iselin, N. J.

Saxl, Victor, Vice-President, Stellite American Corp., 60 E. 42nd St., New York 17, N. Y.

St. John, W. N., Technicraft Laboratories, Inc., Thomaston-Waterbury Rd., Thomaston, Conn.

NORTHERN CALIFORNIA DISTRICT

California Reinforced Plastics Co., R. T. Hughes, Vice-President, 951 Sixty-first St., Oakland 10, Calif.

Bagnard, Gus M., Chief Engineer, Chiksan Co., 330 Pomona Ave., Brea, Calif.

OHIO VALLEY DISTRICT

Dayton Forging and Heat Treating Co., The, Stewart M. DePoy, Metallurgist, 2323 E. First St., Dayton 3, Ohio.

General Electric Co., Major Appliance Div., Ralph G. Thompson, Engineering Manager, Materials and Process Section, Major Appliance Lab., 310 W. Liberty, Appliance Park, Bldg. 2, Louisville, Ky.

Universal Concrete Pipe Co., Inc., Henry A. Wiegand, Western Division Manager, 297 S. High St., Columbus 15, Ohio.

Bodine, Edward George, Engineer, Battelle Memorial Inst., Room 4242, Battelle Memorial Inst., 505 King Ave., Columbus 1, Ohio. [J]

Brams, Stewart L., President, Dayton Chemical Products Laboratories, Inc., West Alexandria, Ohio.

Briley, Harry D., Development Engineer, Deering Air Conditioning Co., 1069 Celestial Ave., Cincinnati 2, Ohio.

Marshall, Lauriston C., Director of Research, Link-Belt Co., 220 S. Belmont Ave., Indianapolis, Ind.

(*Continued on page 78*)

a new catalog....

on FISHER/TAG

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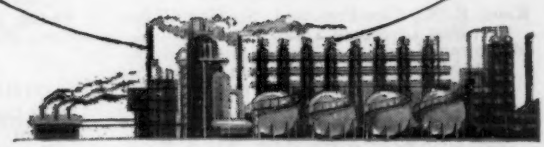

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(*Continued from page 76*)

Middendorp, Howard J., Physical Metallurgist, Wright Air Development Center, Wright-Patterson Air Force Base, Ohio. For mail: 2328 Fauver Ave., Dayton 10, Ohio.

PHILADELPHIA DISTRICT

Barrows, Edward S., Navy Inspector in Charge, Inspector of Naval Material, U. S. Department of the Navy, 17 Brief Ave., Upper Darby, Pa. For mail: 17 Post Office Bldg., Kingston, Pa.

Pake, B. Lewis, Manager Plant Laboratories, Lehigh Portland Cement Co., Allentown, Pa.

Sprague, Oliver A., Chemist, Publicker Industries, Inc., Delaware Ave. and Bigler St., Philadelphia, Pa. For mail: 2308 Margaret St., Philadelphia 37, Pa. [J]

Woolley, Harold O., Jr., Research Engineer, Aircraft-Marine Products, Inc., 323 S. Cameron St., Harrisburg, Pa.

PITTSBURGH DISTRICT

Koos, E. K., Vice-President, Sterling China Co., East Liverpool, Ohio.

McGowan, Louis A., Chief Engineer, Rockwell Manufacturing Co., Du Bois, Pa. For mail: Breezewood Ave., Du Bois, Pa.

Wiebe, Henry J., President and Chief Engineer, Henry J. Wiebe and Co., 434 N. Rock Island, Wichita, Kans.

SOUTHERN CALIFORNIA DISTRICT

Gelvatex Coatings Corp., John D. Beggs, President, 93 N. Arroyo Parkway, Pasadena 1, Calif.

Rezolin, Inc., N. M. Hastings, Chief Chemist, 5736 W. Ninety-sixth St., Los Angeles 45, Calif.

Peterson, Jerome L., Civil Engineer, J. L. Peterson, Inc., 2380 Atlantic Blvd., Los Angeles 22. For mail: 74 Freeman St., Long Beach, Calif.

Pomona Public Library, Business and Industry Div., Margaret S. Gray, Librarian, 380 N. Main St., Pomona, Calif.

SOUTHWEST DISTRICT

Allied Testing Laboratory, Inc., Lawrence L. Chapman, President, Box 8141, Tulsa, Okla.

Daniels, R. P., Chief Chemist, Gulf Oil Corp., Box 701, Port Arthur, Tex.

Manuel, B. B., W. H. Curtin and Co., Box 118, Houston 1, Tex.

WASHINGTON (D. C.) DISTRICT

Uster Corp., D. A. Cicone, Sales Engineer, 2516 Wilkinson Blvd., Charlotte 8, N. C.

Fox, Walter V., Technical Service, Fox Chemical Service, Inc., Berwyn, Md. For mail: Box 392, Berwyn, Md.

Jones, Barclay Gibbs, Research Assistant, Institute for Research in Social Science, University of North Carolina. For mail: Box 813, Chapel Hill, N. C.

Hall, W. M., Jr., Partner, W. M. Hall and Sons, Laboratory, Box 188, Belmont, N. C. [J]

Horner, L. I., Celanese Corporation of America, Box 444, Cumberland, Md.

Howell, A. Leo, Assistant Works Manager, Revere Copper and Brass, Inc., 1301 Winomico St., Baltimore 3, Md.

Oglio, Edward R., Technologist, National Bureau of Standards, Washington 25, D. C.

O'Roark, Charles Edward, Combustion Engineer, Clearbrook Coal Co., Box 446, Cumberland, Ky. For mail: Box 532, Cumberland, Ky.

Taylor, Henry L., Chief Specifications, Thomas B. Bourne Associates, 832 Dupont Circle Bldg., Washington, D. C.

WESTERN NEW YORK-ONTARIO DISTRICT

McKittrick, James P., Chief Chemist, Kendall Refining Co., Bradford, Pa.

Ott, Thomas E., Engineer, H. K. Porter Co., Inc., Buffalo Steel Div., Tonawanda, N. Y.

Winkler, Albert H., Chief Engineer, Automotive Carburetor Engineering, Eclipse Machine Div., Bendix Aviation Corp., Elmira, N. Y.

UNITED STATES AND POSSESSIONS

Bailey, Gordon F., President, Dixie Laboratories, Inc., 201 Beauregard St., Mobile, Ala.

Brewer, Harry M., Chief Chemist, Spokane Portland Cement Co., Old National Bldg., Spokane 8, Wash. For mail: 2207 Empire, Spokane 6, Wash.

Hill, William Crawford, Soils Engineer, Chief of Section, Oregon Highway Dept., Construction Div., Salem, Ore.

Myer, Perry G., Statistician, The Russell Manufacturing Co., Alexander City, Ala. For mail: P.O. Drawer 272, Alexander City, Ala.

Spare, John C., Testing Engineer, North Dakota State Highway Dept., Bismarck, N. Dak. For mail: 1212 Ave., D, Bismarck, N. Dak.

Thompson, Vester J., Jr., Civil Engineer, Vester Thompson Inspection Co., 2650 Goverment St. Ext., Mobile, Ala.

Young, John T., Consultant, 808 W. Madison St., Phoenix, Ariz.

OTHER THAN U. S. POSSESSIONS

Shell Caribbean Petroleum Co., Sales Technical Adviser, Apartado 809, Caracas, Venezuela.

British Columbia Research Council, University of British Columbia, Vancouver 8, B. C., Canada.

Dobles, Rodolfo, Civil Engineer, Minister of Public Works, San José, Costa Rica. For mail: Box 1177 San José, Costa Rica. [J]

Dunwoody, G. C., Chief Engineer, Mephan Ferguson Pty., Ltd., Box Footscray, Victoria, Australia.

Eeman, Leon R., Chief Chemist, St. Lawrence Corp., Ltd., Red Rock, Ont., Canada.

Escuela de Ingenieria, Universidad de Costa Rica, San José, Costa Rica.

Grau, Jaime, General Manager, Amexa, S. A. 56 Norte No. 145, Santa Maria Insurgentes, Mexico 4, D. F., Mexico.

Habraken, Louis J. L., Chief Engineer, Laboratories Dept., Centre Nationale de Rechercher Metallurgiques, 2 Rue Armand Stevart, Liege, Belgium. For mail: 2, Bd. Th. Radoux, Liege, Belgium.

MacPhee, N. Clarke, Technician, Department of Public Works, Chief Engineers Branch, Testing Labs., West Block, Ottawa, Ont., Canada. For mail: 248 O'Connor St., Apt. 3, Ottawa 4, Ont., Canada. [J]

Nottage, W. J., Gyproc Products, Ltd., Cory's Rd., Rochester, Kent, England.

Novella, Estuardo Alfredo, President, Cementos Novella, S. A. Edificio Novella, 9a Alle y 3a. Avenida Sur. Guatemala City, Guatemala.

Ross Ossa, Gustavo, Manager, Cía. Electro Metalúrgica, S. A., Casilla 3463, Santiago, Chile.

Secada, Carlos F., Industrial Engineer, A. F. Wiese Ing., S. A. Carabaya 501, Lima, Peru.

Sondhi, Jagdish Raj, Director, Sondhi, Ltd., Box 66, Mombasa, Kenya, East Africa.

Taub, Ariel, Mechanical Engineer, Government of Israel, Box 2808, Tel Aviv, Israel.

Yoshida, Kiyoji, Head, Concrete Lab., Nippon Soda Co. Ltd., Akasaka Omote-Machi, Tokyo, Japan.

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* J denotes Junior Members.
** S denotes Sustaining Member.

DEATHS...

Cole Coolidge, Director, Chemical Dept. E. I. du Pont de Nemours and Co., Inc. (July 11, 1953). Member of du Pont Research Staff since 1923, having taken a leading part in development of nylon and prene. Representative of du Pont Sustaining Membership in the Society since 1951.

G. C. Davies (of Pottstown, Pa.), until his retirement a few years ago Vice-President, Pilling & Co., Inc., Philadelphia, Pa. (August, 1953). Member of ASTM for 25 years, and active in Committee A-3 on Cast Iron, serving as Secretary from 1914 to 1926.

W. G. Demarest, Manager, Clay Products Assn. of the Southwest, Austin, Tex. (June 15, 1953). Personal member since 1939, and representative of the Clay Products Assn. in the Society since 1943. An active participant in the work of Committee C-15 on Manufactured Masonry Units since 1939, Mr. Demarest was a member of several subgroups, serving as Chairman of Subcommittee VII on Structural Clay Tile for the past three years.

Carroll B. Griffin, Assistant Head, Mechanical Engineering Dept., Research Laboratories, Div., General Motors Corp., Detroit, Mich. (April 30, 1953). Representative of his company since 1952 on Committee E-9 on Fatigue, serving on Subcommittee III on Survey.

John Howe Hall, an outstanding authority in the fields of metallurgical engineering and steel foundry practice, died on August 4, 1953, at his home in the Ridgecroft Apartments, Tarrytown, N. Y. He had been ill since January. A pioneer in the heat treatment of steel, Mr. Hall contributed in many ways to the development of the steel founder's art. He was successively associated with the Bethlehem Steel Co., Taylor-Wharton Iron and Steel Co., and General Steel Castings Corp.; and since 1945 had been engaged in consulting practice, until recently being located in Swarthmore, Pa. A personal member of ASTM since 1910, Mr. Hall rendered valued service through the years on many of the technical committees, including Committees A-1 on Steel, A-3 on Cast Iron, A-10 on Iron-Chromium, Iron-Chromium-Nickel and Related Alloys, E-4 on Metallography, and E-7 on Non-Destructive Testing. For many years he had been a member of the Subcommittee on Definition of Terms Relating to Heat Treatment of Committee E-8 on Nomenclature and Definitions. He had received many honors, including the J. H. Whiting Gold Medal from the American Foundrymen's Society in 1924, and a citation from the Steel Founders' Society of America in 1946. In 1929 he was Henry M. Howe Memorial Lecturer (AIME); and in 1949, Charles Edward Hoyt Lecturer (AFA). He was a prolific writer on foundry practice in steel industry publications.

(*Continued on page 80*)

Let's talk turkey about testing machine *Costs!*

If you're thinking of buying a universal testing machine, chances are you're concerned about costs. You either struggle along without one, make one do the work of two, or buy one below the standard you know you need.

The fact is that most people either have the wrong idea about costs... or they haven't heard of Young.

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(*Continued from page 78*)

Paul E. Jeffers, Consulting Engineer, Los Angeles, Calif. (August 14, 1953). Affiliated with ASTM since 1929, Mr. Jeffers served as Chairman of the Southern California District Council, 1931–1934. Prominent structural engineer, earthquake resistant construction authority, and President of the California State Board of Registration for Civil and Professional Engineers since 1947, Mr. Jeffers was responsible for the structural design on many well-known Southern California buildings, and in June completed a year as a lecturer in engineering at UCLA. Active in many organizations he was one of the founders of the Structural Engineers Association of Southern California, serving as its first president in 1929, and was a past-chairman of the California Legislative Committee of Professional Engineers.

Max Kuniansky, Executive Vice-President, Lynchburg Foundry Co., Lynchburg, Va. (July 21, 1953). Affiliated with ASTM for many years, Mr. Kuniansky was active in the work of Committee A-3 on Cast Iron and numerous of its subgroups. One of the country's best known foundrymen, he was a Past-President of the American Foundrymen's Society, which awarded him its William H. McFadden Gold Medal in 1941.

F. H. MacLaren, Group Leader, Research Dept., Standard Oil Co., (Ind.), Whiting, Ind. (January 11, 1953). Member since 1951.

Francis L. Mark, Asphalt Technologist and Sales Development Engineer, Dewey & Almy Chemical Co., Cambridge, Mass. (July 26, 1953). Member of ASTM since 1945, and of Committee D-4 on Road and Paving Materials, where he made important contributions in a number of the subcommittees. Mr. Mark was also affiliated with the Asphalt Institute and the Association of Asphalt Paving Technologists, and was a member of the Highway Research Board.

NEWS NOTES ON

Laboratory Supplies and Testing Equipment

CATALOGS AND LITERATURE

Instrumentation for Industry—A new issue of the "Beckman Bulletin" features the growing importance of instrumentation to modern industry. A prominent article deals with "seagoing" spectrophotometers and pH meters. New instruments discussed include a high-speed automatic strain gage recorder capable of monitoring up to 200 check points in 5 min, and a precision micro-microammeter for measuring minute currents in nuclear radiation work. Copies can be obtained through requests for BB 11-220.

Beckman Instruments, Inc., South Pasadena 1, Calif.

Instruments—Recently announced by Brush Electronics Co. is a 34-page booklet, "Instruments for Modern Measurements." Published in two colors, it illustrates and describes over 37 different industrial and research instruments produced for: electrical, physical, surface, resistance-welding, textile and electro-acoustical measurements; and ultrasonic energy applications. Available free of charge.

Brush Electronics Co., Sales Promotion Dept., 3405 Perkins Ave., Cleveland 14, Ohio.

Balances—*Bulletin 15C*, recently revised and reissued by Central Scientific Co., illustrates and describes their line of scales, balances, weights, and accessories. Included are the following items: trip scales; general laboratory balances; analytical, torsion, spring, specific gravity, and special-purpose balances. Free on request.

Bulletin 15C, Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

Ultrasonic Metroscope—An illustrated four-page folder issued by J. W. Dice Co. contains the latest information on the new Model MS-101 Metroscope, an ultrasonic instrument for measuring wall thicknesses of metals and for locating internal defects. *Bulletin 1010* lists the following information: principles of operation, metroscope scales, pattern interpretation, crystals, and specifications.

J. W. Dice Co., Englewood, N. J.

General Laboratory Apparatus—A recent issue of the "Eberbach Announcer" contains several articles dealing with scientific equipment. A featured article covers activities of the National Bureau of Standards. This magazine lists micrometer poise balances, variable transformers, jar mills, densitometers, digestion catalyst tabs, demineralizers, counter-rotating stirrers, laboratory filters, and other items for the laboratory.

Eberbach & Son Co., 200 E. Liberty St., Ann Arbor, Mich.

Low Frequency-High Gain Amplifier and Regulated Power Supply—An illustrated four-page folder has been released by Farrand Optical Co., Inc., containing the latest information on this new instrument which can be utilized for thermocouples, thermopiles, and similar type detectors. *Bulletin No. 810* sent on request.

Farrand Optical Co., Inc., Bronx Blvd., & E. 238th St., New York 70, N. Y.

New Handbook of Noise Measurement—This new publication replaces the earlier book, "Noise Primer." Consisting of over 100 pages, it covers the measurement of airborne sounds, including definitions, standards, measuring equipment, procedures, and interpretation of results. Appendices are included covering decibel conversion tables and a catalog section. The purpose of the booklet is to help those who are faced, possibly for the first time, with the necessity of making sound and noise measurements. Copies available at a slight charge.

General Radio Co., 275 Massachusetts Ave., Cambridge 39, Mass.

Constant Pressure and Vacuum Control—A new catalog illustrates and describes a series of Cartesian Manostat instruments. Information includes description, installation, and directions for use. Also covered are descriptions of large and small model absolute and differential manometers, McLeod gages, and flowmeters. Articles feature theory and design of Cartesian Manostats, and information dealing with a simplified absolute and differential manometer.

The Emil Greiner Co., 20–26 N. Moore St., New York 13, N. Y.

Grating Spectrographs—A newly illustrated 16-page catalog describing grating spectrographs is now available from Jarrell-Ash Co. Catalog G2-53 lists information on all Jarrell-Ash spectrographs and also covers accessory equipment and complementary instruments. Copy free on request.

Jarrell-Ash Co., 26 Farwell St., Newtonville, Mass.

Manually Operated Indicators—Just published by Leeds & Northrup Co. is a new 24-page catalog, "Manually-Operated Indicators for Temperature, Electrolytic Conductivity and pH Measurements." Information explains how manually operated portable and panel indicators are used to measure temperature, electrolytic conductivity, or pH. Catalog contains illustrations of indicators and features a convenient arrangement of instruments according to application. A copy of *Catalog ND42* is available upon request.

Leeds & Northrup Co., 4934 Stenton Ave., Phila. 44, Pa.

Packaged Unit Spray Dryers—Now available from Foster D. Snell, Inc., is an eight-page booklet entitled "Snell Packaged Unit Spray Dryers." Completely revised from earlier editions, it provides information on the use of spray dryers and shows diagrams comparing one method of drying products with the method employed by the Snell Spray Dryer.

Foster D. Snell, Inc., 29 W. 15th St., New York 11, N. Y.

Hydrostatic Testing Machines—An illustrated bulletin has recently been announced by Steel City Testing Machines,

(*Continued on page 82*)

Mullen Testers

Built to A. S. T. M. Specifications.

Also Available in Capacities up to 1500 Pounds Bursting Strength

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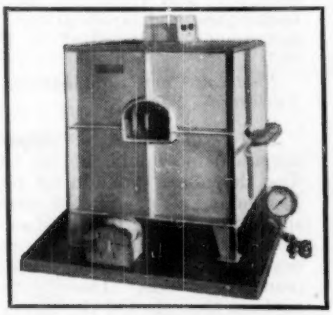
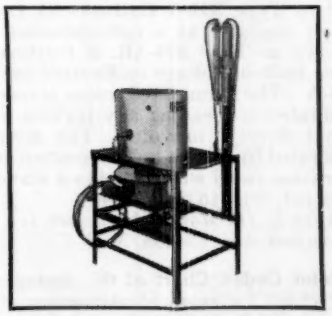


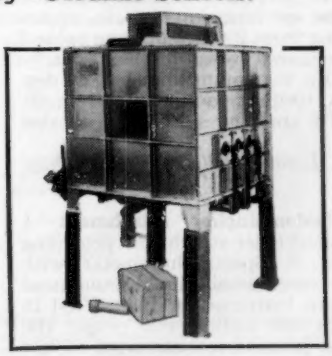
#2150

Setting Space—4½"x6½"x4". Temp. Range—1200°F. to 3100°F. Over-all Dimensions—Approx. 30"x30". Type—Gas-fired, semi-muffle; full muffle. Fuel—Propane, natural or city gas. Stack—none required.



#1800A

Setting Space—Cone plaque holds 22 cones. Temp. Range—Cone 40, as equipped. Over-all Dimensions—33"x 53". Type—Revolving (2 RPM). Floscope controlled. Fuel—Oxygen and acetylene.



#2320

Setting Space—12"x18"x9". Temp. Range—1200° F. to 3200° F. Over-all Dimensions—Approx. 4'x4'. Type—Gas-fired, single valve control. Fuel—Propane, natural or city gas. Stack—not necessary but desirable.

#2350 (not shown)
Setting Space—24"x9"x7¼" high. Temperature Range to 3500°F.

REMMEY

Dependable Refractories

RICHARD C. REMMEY SON CO., PHILADELPHIA 37, PENNA.

(*Continued from page 80*)

Inc., describing three machines designed and built by the company for hydrostatic testing. Form H 353, free of charge, explains that equipment of this type is designed and built to meet customers' specifications and outlines type of information required in advance.

Steel City Testing Machines, Inc., 8817 Lyndon Ave., Detroit 21, Mich.

High Resolution N-M-R Spectrometer—Just announced by Varian Associates is Publication No. 40, a new data bulletin with illustrations and descriptions of the Model V-4300 High Resolution n-m-r (nuclear magnetic resonance) Spectrometer. The new instrument is described as a basic laboratory research unit which is used for rapid non-destructive analyses of chemical bonding situations. The publication includes further specific data on the spectrometer and suitable magnet system.

Varian Associates, 508 Hansen Way, Palo Alto, Calif.

INSTRUMENT NOTES

New Dual Extensometer—A Microformer type extensometer designed to produce stress-strain diagrams with high strain magnifications and low magnifications respectively below and above the elastic limit of materials is announced by Baldwin-Lima-Hamilton, Corp. The TS-M Dual Extensometer is used with a recorder of the Microformer type, employing these variable miniature transformers for transmission of strain variations. Dual magnifications are accomplished during any tension test by switching manually from one to another of the Microformers on the extensometer when any selected value of strain or stress is reached.

Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.

Torsion Test Device—The new Schaevitz torsion device to produce pure torsion on a tension testing machine has been announced by Baldwin-Lima-Hamilton Corp. Test specimens up to $^3/_4$ in. square and ranging from 2 to 12 in. long (plus 2 in. to be engaged by torque bars) can be twisted to a maximum angle of 24 deg. Maximum torque load is 60,000 in.-lb, obtained by applying a 12,000 lb tension load.

Baldwin-Lima-Hamilton Corp., Phila. 42, Pa.

New Photomultiplier Attachment—A new photomultiplier attachment providing the Model B Spectrophotometer with greatly increased sensitivity is announced by Beckman Instruments, Inc. Used in the 320 to 600 millimicron range, the attachment permits measurement of low light levels in transmission and reflectance work. Further information can be obtained by requesting Data File 331-220.

Beckman Instruments, Inc., South Pasadena 1, Calif.

Electric Utility Laboratory Gravity Ovens—Blue "M" Electric Co. announces its newly redesigned series of Electric Utility Laboratory Gravity Ovens for analytical laboratory and general laboratory work in the chemical, medical, and metallurgical field, involving baking, drying, preheating, aging, sterilization, conditioning, and tempering. These new designs provide greater ease of operation and more versatility in use.

Blue M Electric Co., 306-308 W. 69th St., Chicago 21, Ill.

New Spring Tester—A newly developed medium duty tester has recently been announced by the Carlson Co. This spring-testing instrument tests loads and deflections of medium size compression and extension springs and has a capacity up to 100 lb. Descriptive bulletin available on request.

The Carlson Co., 277 Broadway, New York 7, N. Y.

New Chart of the Elements—A new periodic chart of the elements has been announced by Central Scientific Co. Information is conveniently arranged and atomic weights and numbers appropriately placed in relation to the symbol of the elements. Three types of charts are available. Complete details may be obtained upon request.

Central Scientific Co., 1700 Irving Park Rd., Chicago 13, Ill.

New Torsion Spring Tester—John Chatillon and Sons recently introduced a new universal and production tester for spiral and torsion springs, the Torsion Spring Tester, Model No. 735-S. It will test spring capacity up to 2000 g cm. Torsion is measured to 0.1 g cm with deflection measured to $\frac{1}{2}$ deg. Further information may be obtained from Engineering Department.

John Chatillon & Sons, 85 Cliff St., New York 38, N. Y.

Radiation Supervisor—A new Radiation Supervisor, Model DZ 14, designed to provide continuous automatic monitoring of radiation in the laboratory has been developed by Detectolab, Inc. The instrument has built-in Aural and Visual Alarm Systems and adjustable sensitivity. It is a universal type control instrument for use in the laboratory to prevent errors in counting and for other isotopes work.

Detectolab, Inc., 6544 Sheridan Rd., Chicago 26, Ill.

Rack-Mounted Oscillograph—The Instrument Division, Allen B. Du Mont Laboratories, Inc., has an electrical equivalent of Type 304-A Cathode-ray Oscillograph available as a rack-mounted unit. Known as Type 304-AR, it features the same built-in voltage calibration as Type 304-A. The illuminated screen is specially calibrated for reading any portion of the signal directly in volts. The screen is calibrated by a push-button control on the operating panel which applies a standardizing potential to the screen.

Allen B. Du Mont Laboratories, Inc., 760 Bloomfield Ave., Clifton, N. J.

Color Coded Chart of the Isotopes—A new chart for rapid identification of isotope half-life and nuclear stability has recently been prepared by Harshaw Scientific, Division of the Harshaw Chemical Co. With the use of 8 colors this chart, designated as H-10950 Chart of the Isotopes, is arranged to make available, in easily usable form, all useful information about isotopes. A guidebook sent with each chart outlines instructions for reading the chart and summarizes applications.

Harshaw Scientific, Division of the Harshaw Chemical Co., Cleveland 4, Ohio.

Robot-Eye Units Monitor Uranium Rolling Process—Radiation detection devices comprise the heart of a newly developed robot system 10 times faster and 2 to 5 times more accurate than previous systems in monitoring critical temperatures during uranium rolling operations, according to an announcement by the Minneapolis-Honeywell Regulator Co. The objective of this new system is to improve the accuracy of temperature measurements which are important to uranium and other rolling processes. The radiation devices detect the temperature—or heat—of the uranium ingot and relay the information to a series of electronic recording instruments. This information permits a single operator to make necessary adjustments.

Minneapolis-Honeywell Regulator Co., Industrial Division, 5060 Wayne Ave., Phila. 44, Pa.

New Metal Hardness Testers—The first hand-operated metal hardness testers to provide automatic load changing and magnified optical readings have been announced by the Opplem Company, Inc., importers of the Galileo line of optical and precision instruments. The new instruments are the Galileo Superficial Hardness Tester, providing loads starting at 5 kgm, and the Galileo Standard Hardness Tester which handles Rockwell measurements from 30 to 1000 Brinell units, Brinell tests, special loads and Vickers measurements. Literature available on request.

Opplem Co., Inc., 352 Fourth Ave., New York 10, N. Y.

Turbidimeter—A visual extinction type turbidimeter for rapid sulfur and sulfate determination is announced by Parr Instrument Co. This instrument, described in a new 4-page bulletin, is used mainly for determining sulfur in solid and liquid fuels, cement, boiler water, and in other industrial material. Copies of Specification No. 2400 will be mailed on request.

Parr Instrument Co., 211 53rd St., Moline, Ill.

Densitometer for Partition Chromatography and Paper Electrophoresis—A new densitometer, Model 425, has recently been announced by Photovolt Corp. The main features of this model are its simplicity, convenience and speed of operation, minimum of operating controls, high accuracy, and versatility for the various techniques and applications. This new instrument is described in *Bulletin No. 755.*

Photovolt Corp., 95 Madison Ave., New York 16, N. Y.

Oil Oxidation Test Apparatus—New apparatus now available for Oil Oxidation Test has been announced by Technical Equipment Co. This apparatus is designed for testing the resistance to oxidation and sludging of automotive and aircraft oils, steam turbine oils, and electrical transformer oils. Descriptive literature explains that the Oil Oxidation Apparatus meets specifications of several standard oxidation tests, including ASTM Methods D 943[1] and D 670.[2]

Technical Equipment Co., 743 Dwight Way, Berkeley 10, Calif.

[1] Tentative Method of Test for Oxidation Characteristics of Inhibited Steam Turbine Oils (D 943 – 47 T), 1952 Book of ASTM Standards, Part 5, p. 409.

[2] Tentative Methods of Test for Sludge Formation in Mineral Transformer Oil (D 670 – 42 T), 1952 Book of ASTM Standards, Part 5, p. 269; Part 6, p. 1196.

(*Continued on page 84*)

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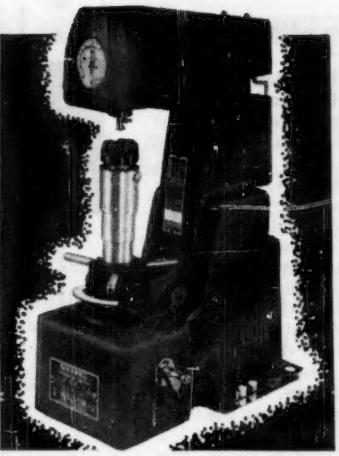

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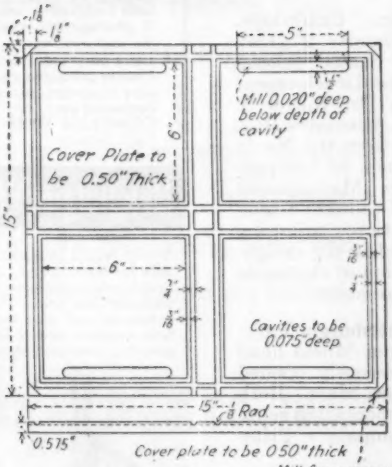

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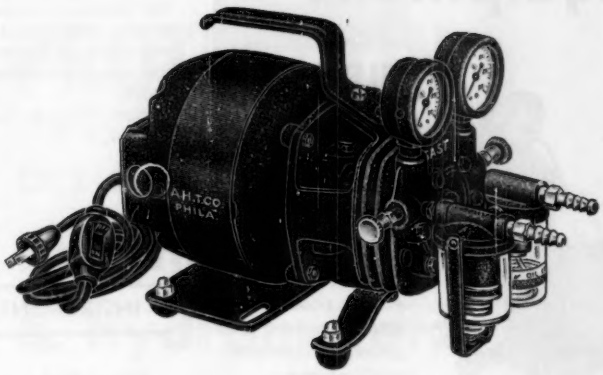

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GAST PORTABLE ROTARY AIR BLAST AND SUCTION APPARATUS, A. H. T. Co. Specification. A quiet, air cooled, motor driven unit complete with vacuum and pressure gauges and thermal overload circuit breaker. Suitable for intermittent operation at pressures not exceeding 25 lbs., or vacuums not exceeding 27 inches of mercury.

Consisting of a pump with four-vane rotor which is integral with the shaft of a ¼ h.p., 1725 r.p.m. motor. With air filters and oil trap directly behind inlet and outlet. Vacuum gauge reads 0 to 30 inches of mercury, and pressure gauge reads 0 to 30 lbs. With needle valves for precise regulation of pressure and vacuum.

The combined filter, muffler and trap on the pressure side consists of a heavy glass bowl with porous stone filter which is easily cleaned and which does not require replacement. The filter on the vacuum side is a combined oiling and air filtering device enclosed in a screw neck glass reservoir in which oil level can be observed at all times.

SPECIFICATIONS:

Capacity, cu. ft. of free air per minute (atmospheric pressure)	1.3
Cu. ft. of free air at 25 lbs. pressure (for 10 minute periods)	0.95
Maximum vacuum, inches of mercury	27
Maximum pressure, lbs.	15
Speed, r.p.m.	1725
Current consumption on 115 volts, amperes	4
Number of blast lamps (M.I.T. or equal)	4
Floor space, inches	15 x 6½
Net weight, lbs.	34

1032-A. Rotary Air Blast and Suction Apparatus, Gast Portable, A. H. T. Co. Specification, as above described, complete with pressure and vacuum gauges and thermal overload circuit breaker, filters, carrying handle and 10 ft. of cord with snap switch and plug. With ¼ h.p. motor, for 115 volts, 60 cycles, a.c. **63.25**

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(Continued from page 82)

New Photographic Techniques Permit Precise Study of Machines and Processes in Action—It has been announced that high-speed photography and time-lapse photography are now being offered as a field service by Sam Tour & Co., Inc. By using a special camera, high-speed motion pictures show clearly and in detail the actions of any body or mechanism moving at either constant or changing high velocities. With time-lapse photography, processes that normally proceed very slowly are photographed at fixed intervals so that the action of several hours, days, or weeks can be condensed into a smoothly flowing sequence of several minutes. Additional information can be obtained from the company.

Sam Tour & Co., 44 Trinity Place, New York 6, N. Y.

INSTRUMENT COMPANY NEWS

Alfred Bicknell Associates, Inc., Cambridge, Mass.—Announcement was recently made of the appointment of Dr. Kenneth W. Gardiner to the research staff as consulting collaborator. He will assist Dr. Frederick G. Keyes, Director of Research, in scientific instrument design and development. Dr. Gardiner previously worked as Research Associate, Department of Biology, MIT, and Department of Medicine, Harvard Medical School.

Applied Research Laboratories, Glendale, Calif.—Paul S. Goodwin has been appointed engineering manager for Applied Research Laboratories according to a recent announcement by R. W. Lindhurst, vice-president and chief engineer.

Baird Associates, Inc., Cambridge, Mass.—Rear Admiral Thomas F. Halloran, retired, has been named general manager of the Transistor Development Laboratory, according to Dr. Walter S. Baird, President of Baird Associates, Inc. Admiral Halloran retired from the Naval Service in 1948. Since then, he has participated in the Advance Management Program at the Harvard Graduate School of Business Administration, following which he has been engaged in the design, development, and production of electronic and electromechanical equipment.

Fisher Scientific Co., Pittsburgh, Pa.—Russell Bennett and Norma Musto head the New England office recently opened at 10 Brattle St., Cambridge, Mass. Both are graduates of the instrumentation seminar conducted in the company's Pittsburgh headquarters.

Leeds & Northrup Co., Philadelphia, Pa.—Election of I. Melville Stein as president of Leeds & Northrup Co. was announced recently by the board of directors. Mr. Stein, formerly executive vice-president, succeeds Charles S. Redding who becomes chairman of the board. D. H. Schultz, who has been secretary and treasurer since 1940, succeeds Mr. Stein as exectuve vice-president while retaining the duties of treasurer. George W. Tall, Jr., vice-president, assumes the additional post of secretary.

(Continued on page 86)

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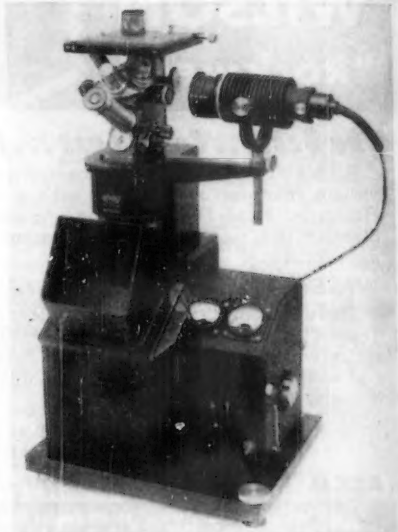

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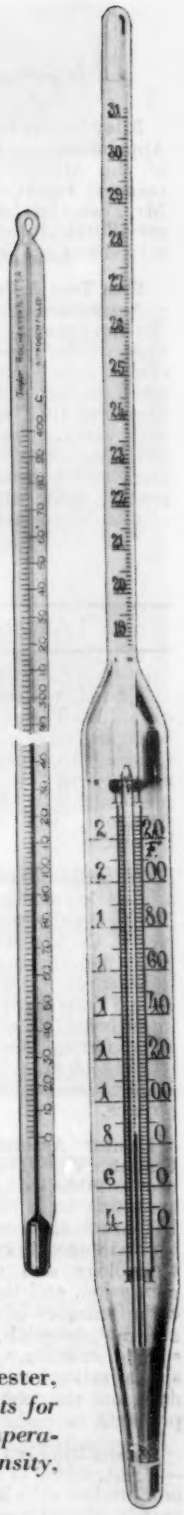

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IN HOME AND INDUSTRY

(*Continued from page 84*)

Riley Stoker Corp., Worcester, Mass.—Appointment of F. E. Foster as Manager of the Metallurgical Division was announced recently by Riley Stoker Corp. Mr. Foster has had extensive experience in metallurgical investigations, pressure vessel welding, and materials engineering.

Sam Tour & Co., Inc., New York, N. Y.—Announcement was recently made of the appointment of Joseph Stein as supervisor of the non-destructive testing division of Sam Tour & Co., Inc. Mr. Stein, who graduated from the University of Zurich in 1936, has had broad experience with various phases of the atomic energy program. He will supervise laboratory and field testing projects using radiographic, sonic, ultrasonic, and other types of non-destructive testing techniques.

LABORATORY NEWS

Bjorksten Research Labs., Inc., Chicago, Ill.—The new address of the Chicago office and laboratories is 1525 E. 53rd St., Chicago 15, according to a recent announcement by Dr. Johan Bjorksten, president. Dr. Edwin L. Gustus, vice-president, will continue to head this branch.

Cenco Corporation, Chicago, Ill.—In the annual statement, recently released, announcement was made that Central Scientific Co.'s new research and development laboratories would be completed in August. The new laboratories will enable the company to extend its activities into the fields of chemistry and electronics, the report said, explaining that previously its development of new products had largely been confined to the field of physics.

Hunter Associates Laboratory, Falls Church, Va.—This new laboratory has been established at 5421 Brier Ridge Rd. according to a recent announcement by Richard S. Hunter, Director. The laboratory will operate in the field of appearance technology and offers research, instrumentation, and technical service on optical appearance of manufactured products and raw materials. Services include consulting, testing, and developing, with specialization in furnishing information and data on the photometric properties of products.

Owens-Illinois Glass Co., Toledo, Ohio—Construction of a new Technical Center now underway will consolidate the company's general research program with the engineering activities of its various divisions. According to Oscar G. Burch, vice-president, research and engineering, who will direct its operations, "when completed it will be one of the most advanced technical centers in the glass industry and will be capable of carrying a project from the drafting board stage through the laboratory and pilot plant to tests under conditions encountered in commercial production." The Center is scheduled for completion in the fall of 1954 and will be occupied by 350 engineers, scientists, and technicians.

Foster D. Snell, Inc., New York, N. Y.—The Foster D. Snell organization announces the formation of an Engineering Physics Department in the Engineering Division of the firm. One of the primary functions of the new department will be to study shock and vibration and their effect on packaged and unpackaged instruments and delicate equipment. Joseph P. McGill will be in charge of the Engineering Physics Department.

Virginia Polytechnic Institute, Blacksburg, Va.—A universal testing machine with a double torque-bar weighing unit has just been installed in the Wood Research Laboratory of Virginia Polytechnic Institute. The machine has a capacity of 12,000 lb and a sensitivity of $\frac{1}{10}$ lb and is provided with an automatic electronic recorder to produce stress-strain curves at magnifications from 1:1 to 1000:1 by the turn of a switch.

Wilson Chemical and Testing Laboratory, El Paso, Tex.—Harold W. Wilson, formerly Chief Analytical and Physical Testing Chemist with the American-Marietta Co. of Chicago, Ill., recently announced the opening of this new laboratory. The laboratory is designed, equipped, and staffed to conduct chemical analyses, physical testing, and ultraviolet exposure testing of all types of surface coating materials.

A Recording Analytical Balance

AN ANALYTICAL balance recently developed at the National Bureau of Standards automatically makes a continuous record of changes in weight, following even rapid changes, with good accuracy. The new instrument is being used at the Bureau to record changes in weight of samples of complex minerals during thermal decomposition. Because it combines versatility and convenience with low cost, the device may be suitable for many other laboratory applications requiring a record of weight as a function of time.

The NBS instrument uses a conventional laboratory balance modified so that changes of weight are balanced by adjustment of a magnetizing current. The balancing force results from the interaction of the magnetic field of a solenoid with the field of a permanent bar magnet suspended, inside the solenoid, from one side of the balance. Automatic balancing is achieved by means of

(*Continued on page 88*)

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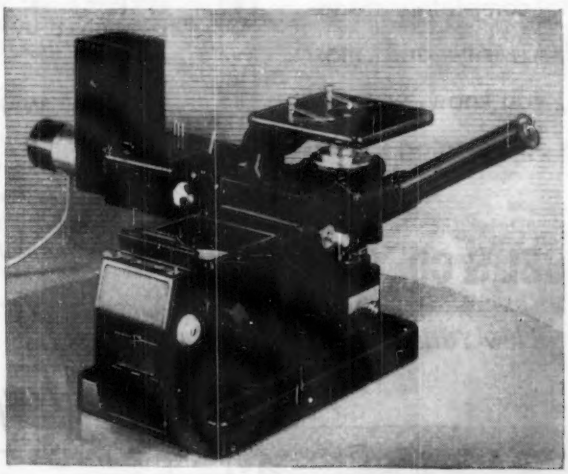

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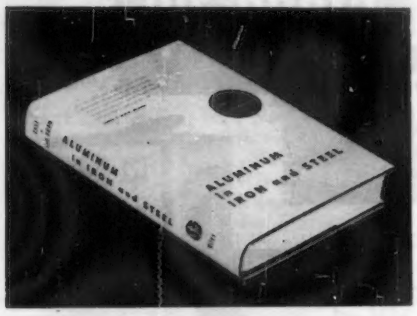

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(*Continued from page 86*)

a photoelectric sensing arrangement in which a beam of light is reflected to a dual phototube from a mirror mounted on the balance beam. The two sections of the phototube are connected in a bridge circuit, the output of which is amplified and applied to the solenoid. Any change in weight tending to produce unbalance is promptly counteracted by whatever change of solenoid current is needed to maintain balance (within a small fraction of a division of the balance scale). An electronic damping circuit eliminates oscillations and enables the electrical output of the instrument to follow faithfully very rapid changes of weight.

The record of weight changes is obtained by connecting a resistor in series with the solenoid and applying the voltage developed across this resistor to a commercial recording potentiometer of the strip-chart type. Since the balancing force exerted on the magnet is directly proportional to the current through the solenoid, the weight scale is linear and the recorder is easily made to read directly in milligrams. By substituting a different dropping resistor, a different magnet, or both, full scale ranges of as little as 10 mg or as much as a 1 g are obtained. For ranges of 100 mg or more, accuracy is better than 0.5 per cent of full scale. When the damping control is properly adjusted, an abrupt change in weight as great as 1 g can be recorded in 3 sec without excessive hunting.

The balance has been used at the Bureau to provide thermochemical data for a study of the kinetics of the dehydration reaction of kaolins. This weighing technique has proved ideally suited to the automatic recording of both weight-change and differential temperature curves on a single chart, and has made it possible to obtain large amounts of needed data with a minimum of attention from laboratory personnel.

An example of a potential application of the NBS recording balance is in the drying of cotton fibers, or other moisture-absorbent material, to constant weight. A commercial manufacturer of instruments has already indicated an interest in constructing a model of the NBS instrument tailored to this particular use. Another contemplated use is in the study of the high-temperature oxidation resistance of certain of the cermets that are now being tried as turbine blade materials.

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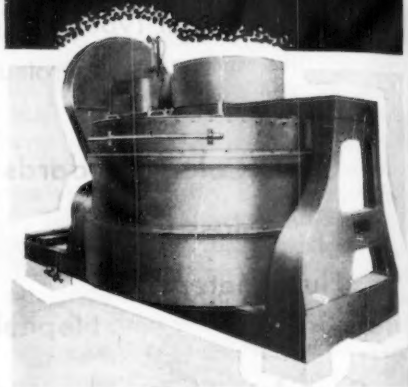

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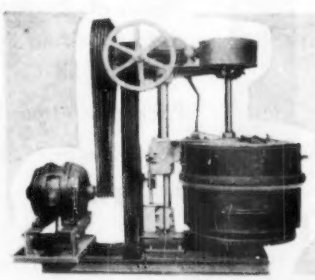

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